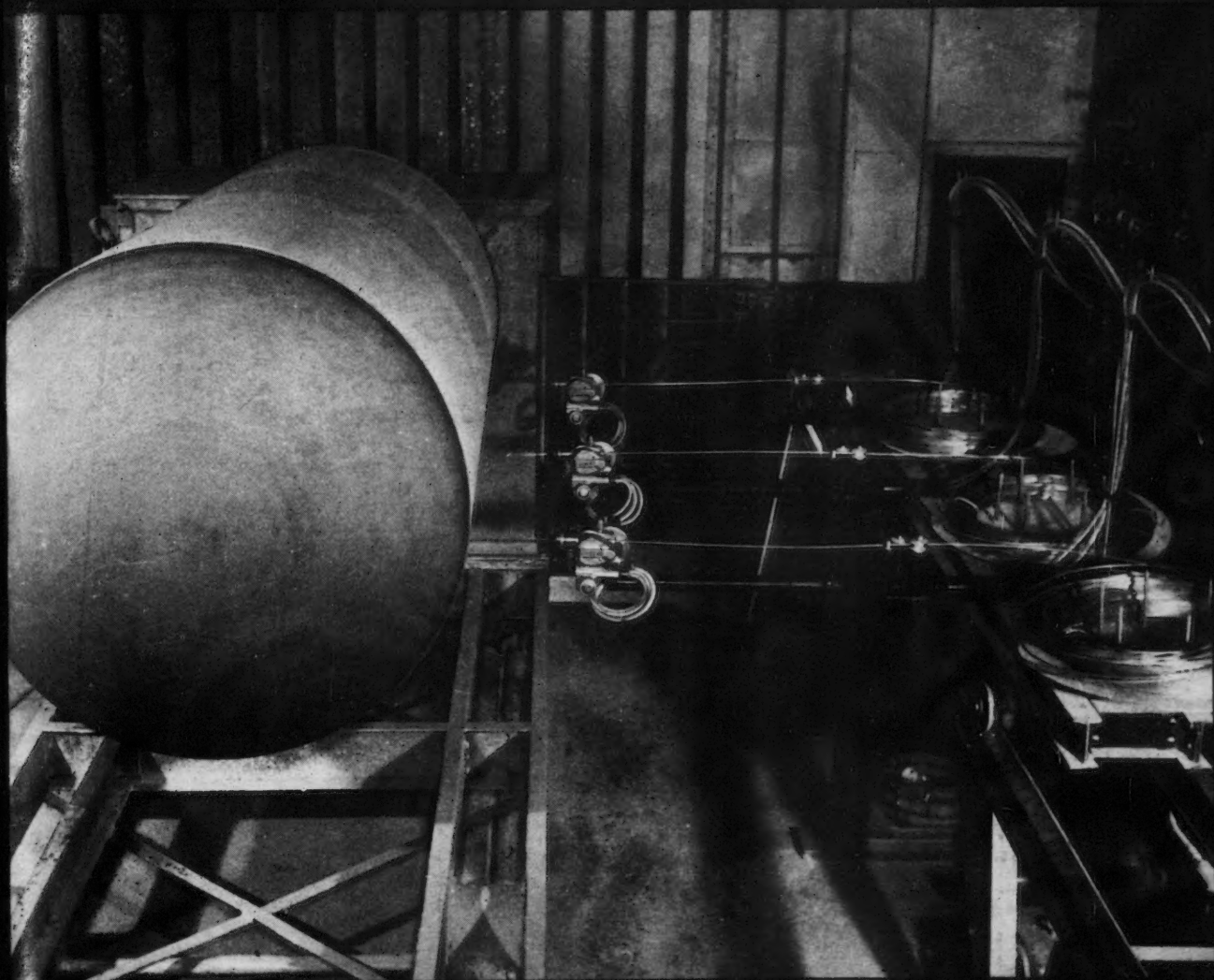


# Corrosion

Official Publication  
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



APRIL, 1931



# NO-OX-ID *is easy to apply...* **hot or cold**

Left illustration: Hot applied NO-OX-ID and NO-OX-IDized Wrapper by stationary machine in the yard preparatory to line delivery for stringing and welding.

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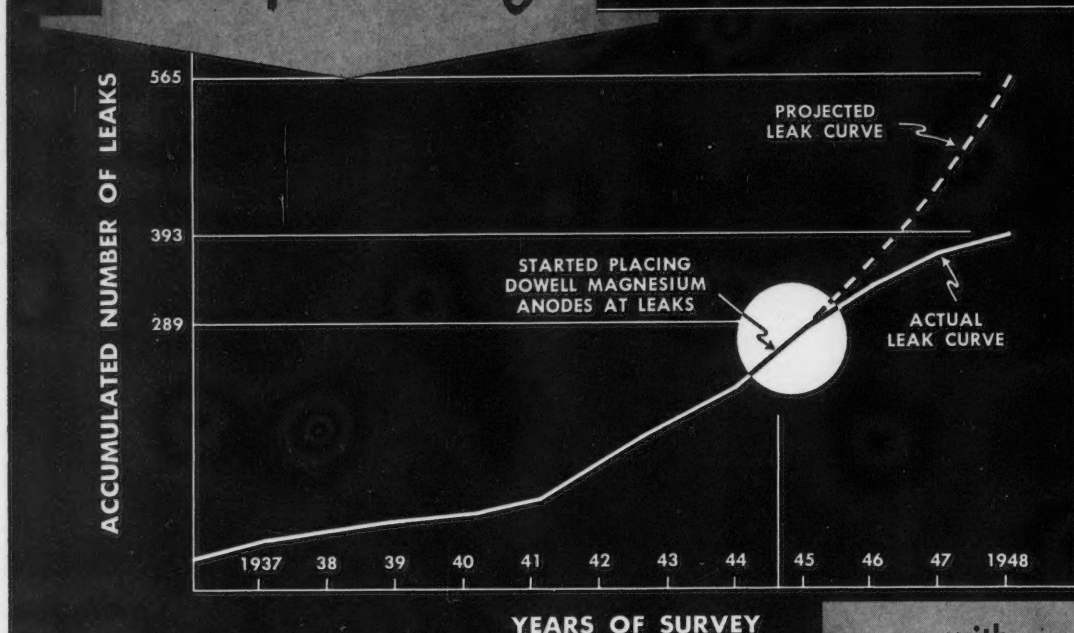
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Data on "Carclad" Three-Coat System courtesy Sherwin-Williams Company, 101 Prospect Avenue, N. W., Cleveland 1, Ohio

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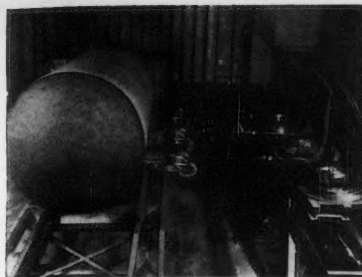
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devoted entirely to  
**CORROSION**  
research and control

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APRIL, 1951

No. 4



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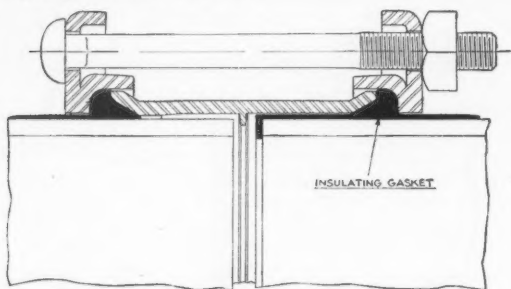


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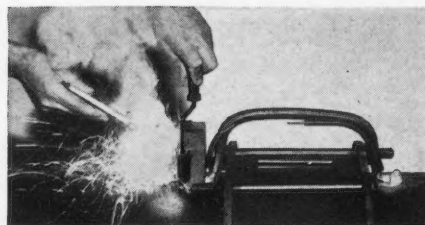
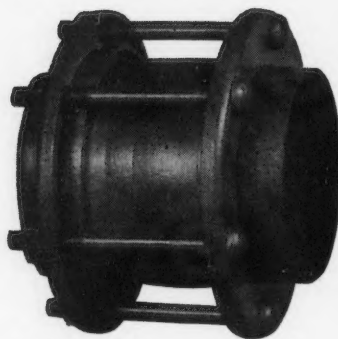


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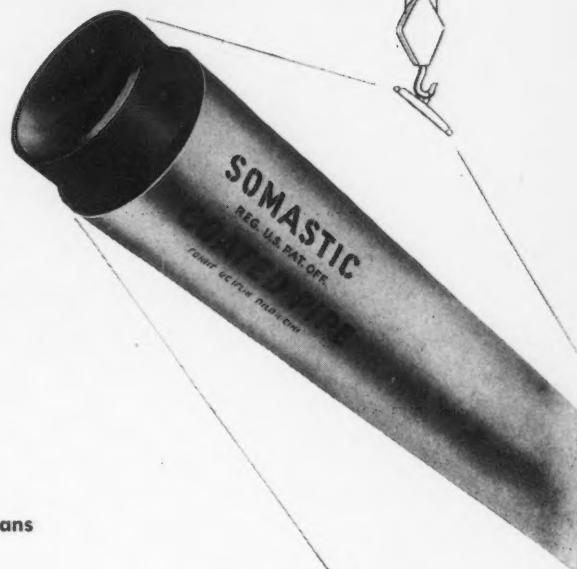
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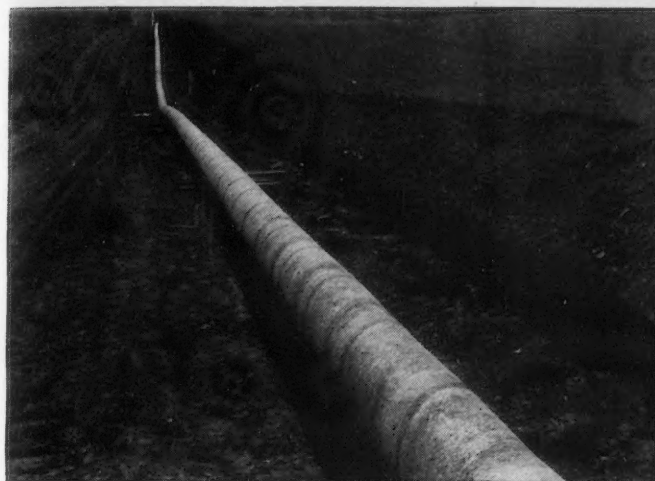
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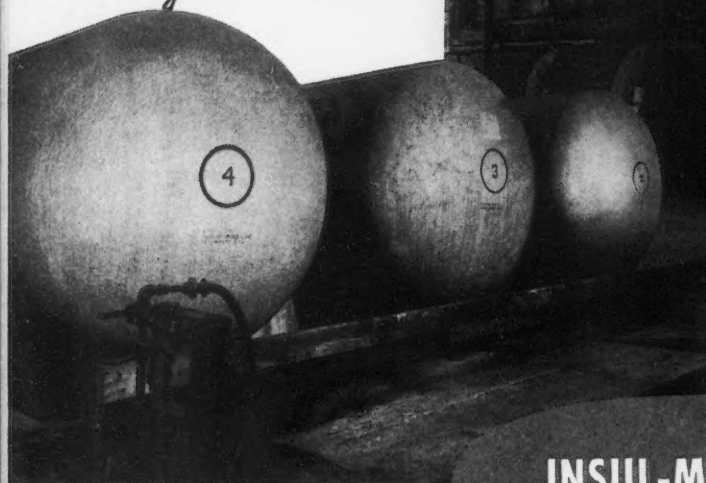
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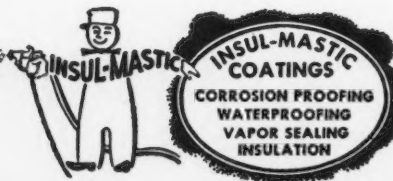
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# THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

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## Technical Practices Committee 15— Corrosion Control in the Transportation Industry

By M. A. WILLIAMSON

ORGANIZATION OF Technical Practices Committee 15 was started early in 1949. It was the intent that this committee should ultimately concern itself with corrosion problems in all fields of transportation, such as automobiles, trucks, buses, railroads, aircraft, etc., but excluding pipe lines and marine transportation. It was decided at the start to organize the committee to deal with corrosion problems of the railroad field only, and to so plan this group that it could become a sub-committee at a later date and also to serve as a guide in the formation of similar sub-committees concerned with corrosion problems in other fields of transportation. The first meeting was held in October 1949.

Thus far, the committee has concerned itself only with corrosion problems in the railroad industries. The present objectives, which will later be the objectives of the sub-committee on railroads, are as follows:

- To stimulate and encourage research and interest in determining the causes of and methods of controlling corrosion in the railroad industry.
- To facilitate the exchange of knowledge and ideas among personnel actively concerned with problems relating to corrosion control in the railroad industry and railroad supply field.
- To provide a means of circulating to interested parties in the railroad industry new and improved techniques and methods of corrosion control.

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Chicago, Illinois

(Continued on Page 114)

- To promote standardization of terminology, methods, equipment, etc., where desirable.
- To serve as a source of information on corrosion work being conducted in the transportation field.



M. A. Williamson

Committee TP-15 has held five meetings and has furthered the above objectives by discussion of mutual problems, circulation of important information, contributing to symposia on corrosion, and conducting a survey of railroads and railroad equipment suppliers to determine what corrosion problems are felt by the railroads to be of importance and to find out what research work is currently being carried out by the railroads. As a part of its program, Committee TP-15 is planning to issue a Corrosion Newsletter which will be distributed to the major American railroads. The Newsletter will present papers on various phases of corrosion prevention and will serve as a medium whereby results of current investigations may be reported. The first issue of this Newsletter has not yet been circulated. It may or may not be continued depending upon its reception by the railroads and whether or not it meets a required need.

Members of Committee TP-15 as of February 1, are the following:

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## Cathodic Protection of an Active Ship In Sea Water—Part II\*

By K. N. BARNARD\*

### Introduction

A PAPER,<sup>1</sup> presented at the Sixth Annual Conference of the National Association of Corrosion Engineers at St. Louis, Mo., described the controlled magnesium anode system of cathodic protection installed on H.M.C.S. "New Liskeard" when in drydock June 1949, and recorded the hull potential measurements from June to December 1949. This record indicated that the hull was effectively protected from corrosion during the seven months period.

The ship was drydocked on May 12, 1950 and this article describes the results of the inspection at that time and gives a graph of the anode current-time and hull potential-time relationship for the complete period of eleven months between drydockings.

The drydock inspection verified the assumption, based on hull potential readings, that the hull was well protected throughout the period.

### Activity of Ship October 25, 1949 to May 12, 1950

As stated in the previous report, "New Liskeard" was taken out of active service on October 25, 1949 and kept at a jetty berth while changes were being made in the superstructure. The ship remained inactive until the end of March 1950. During April and early May a number of relatively short trips in and out of the harbor were made.

### Hull Potential and Anode Current Readings

The graphs of the hull potential and anode current readings vs. time for the period June 23, 1949 to May 9, 1950, are shown in Figure 1. It can be seen that the value of the hull potential for the greater part of the time was 800 mv or higher and that the current to maintain this potential was between 20 and 35 amperes. As to be expected, the hull potential was highest during January, February and March, when the sea water was coldest and the polarization film had been building up undisturbed for a long period. It is

### Abstract

H.M.C.S. "New Liskeard" was drydocked May 12, 1950, eleven months after magnesium anodes were fitted to each bilge keel. No corrosion was observed on the underwater hull except in a few re-entrant places. The general condition of the underwater paint was fair and the ship was relatively free from fouling growth. The current required for protection varied between 20 and 35 amperes, depending on the conditions under which the ship operated. The consumption of magnesium was 435 lb. for the 11-month period.

The results show that it is possible and practical to use magnesium anodes to protect cathodically an active ship in sea water and that the measurement of the "hull potential" is an effective criterion as to how much current should be applied at a given time. The possibility of lengthening the period between drydockings of active ships from one year to two years is indicated.

probable also that the temperature of the sea water affects the ease of polarization of the hull. The anode current was therefore lowest during this period as the current is to a large extent cathodically controlled when the ship is well polarized to a hull potential of 800 mv or more.

The adverse effect on the hull potential of a protected ship when allowed to make metallic contact with an unprotected ship is shown in many instances in the hull potential curve of Figure 1. The type of metallic contact varied; in some cases contact was made through a metallic steam hose, in others by steel hawsers or by wire bound fenders, and, in one instance, by a rubbing contact between the two hulls. The readings shown in the graph were usually taken when the two ships were in metallic contact, and was the approximate mean of the hull potentials of the two ships—a little lower than that of the protected ship and higher than that of the unprotected one. The change in hull potential when the contact was broken (by lifting the metallic hose) is shown in two instances in the December readings. When contact was broken there was a reasonably rapid rise in hull potential with time to the value obtained before contact.

Toward the end of April and during May, 1950, when the ship was making frequent short trips in

\* Submitted November 8, 1950.

\* Defence Research Board, Naval Research Establishment, Halifax, Nova Scotia.

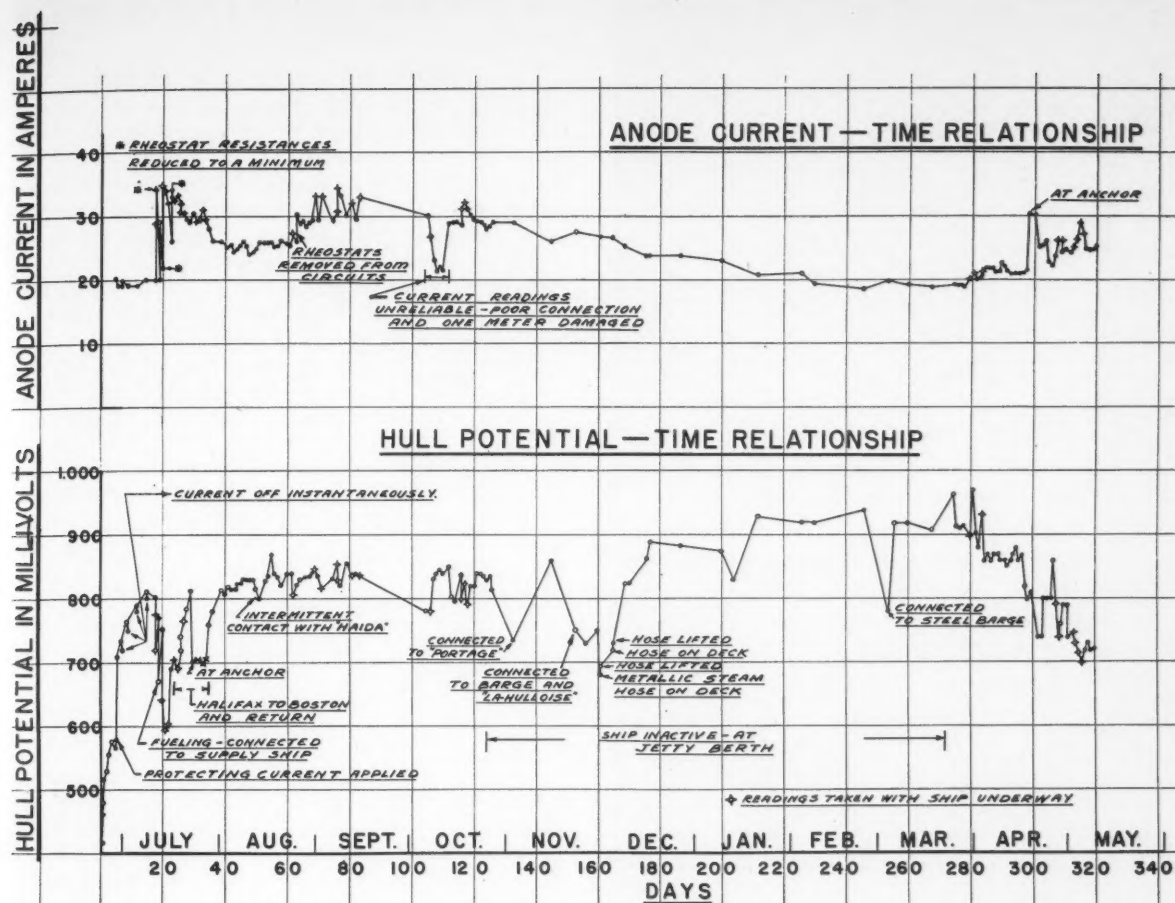


Figure 1—H.M.C.S. New Liskeard, 23 June 1949 to 9 May 1950.

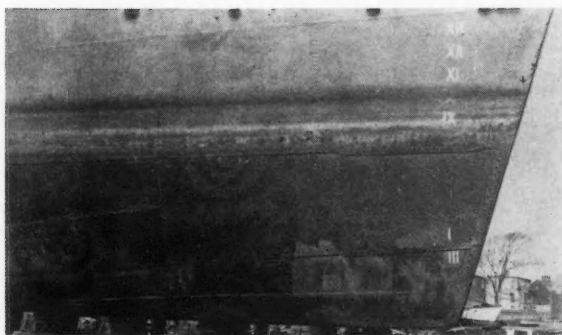


Figure 2—Bow, starboard side, showing general condition of fouling which consists mostly of slime and scattered tufts of weeds. Small areas near bow rubbed off with wire brush to show condition of paint.



Figure 3—Stern, port side, showing general condition of fouling which consists mostly of scattered tufts of weeds.

and out of harbor, there was a falling off of hull potential. Since all resistances other than lead and ammeter resistances had been removed from the anode circuit August 25th, 1949, it was not possible to increase the current output of the anodes, and from April on the maximum current output of the anodes was not quite sufficient to maintain the hull potential

at 800 mv with the ship underway. There were two main reasons for this: a) the maximum current available from the anodes had decreased due to a decrease in length and active area of the anodes and the presence of a copper impurity in the anode (see below); b) the overall condition of the paint on the underwater hull had deteriorated with time and a larger



Figure 4—Close-up of typical outlet showing presence of mussels. Note absence of rust around outlet.

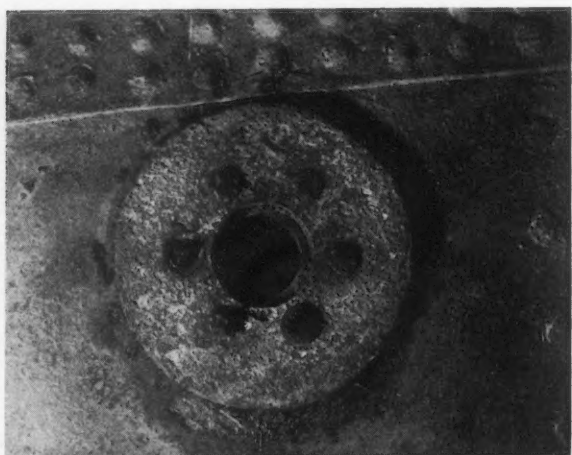


Figure 5—Close-up showing typical appearance of a zinc (Grade II) anode, normally fitted around outlets, after a year's service. Note inert appearance of zinc and presence of rust adjacent to the anode and on its securing bolts.

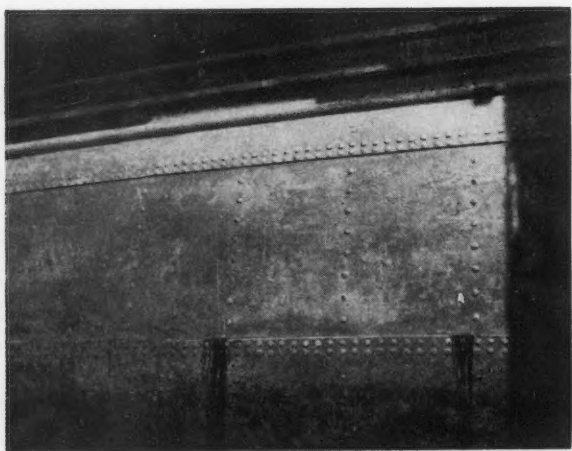


Figure 6—Starboard side amidships showing area rubbed bare of paint by jetty fenders. The severe pitting of the hull plating that can be seen here occurred prior to June 1949.

current was required to protect the ship than when the paint was fresh.

#### Drydocking Inspection, May 12, 1950

**Fouling:** In general the ship would be considered relatively free of fouling growth compared to other ships in service for one year coated with similar antifouling paint. The fouling consisted of a light layer of grass and slime near the bow and scattered tufts of weeds on the bottom. Photographs of the bow and stern, shown in Figures 2 and 3, were taken shortly after the ship was drydocked and indicate the amount of fouling present. A few mussels were present at outlets and inlets as shown in Figure 4.

**Corrosion:** No corrosion was observed on the outer portion of the hull and shafts or around openings in the hull. A slight amount of corrosion, consisting of scattered rust mounds  $1/8$  inch to  $1/4$  inch in size, was seen at the innermost section of the main injection inlet and on the propeller shafts under the rope guards (eddy plates). The corrosion on top of the asdic dome was heavier than elsewhere, the rust mounds being about  $1/4$  inch in size and fairly thickly scattered. However in no instance did the amount of corrosion observed in recesses or covered areas compare with the amount normally seen when zinc anodes (usually Grade 2\*) are used on Naval ships in similar service. A typical illustration of the corrosion around a zinc anode on such ships is shown in Figure 5.

**Condition of the Paint:** The general condition of the paint on the hull was fair (see Figure 2 where a patch of slime has been brushed off near the bow). Areas amidships (about 125 sq. ft. on the port side and 100 sq. ft. on the starboard) had been rubbed completely bare of paint, as shown in Figure 6, by the jetty fenders. These areas were bright and shiny on the starboard side and had a very light growth of grass on the port side. The bare areas on the port side had a somewhat dull appearance as if they might have been coated with a very thin film of cathodic deposit. In some places the current from the magnesium anode

\* Analysis of typical zinc anode gave 0.24% lead, 0.020% iron and 0.13% cadmium.



Figure 7—Port side forward of bilge keel showing small area of cathodic deposit formed where old rust scale had been stripped from hull by the protecting current.



had loosened the rust scale that had formed under the paint film prior to June 1949 and the loosened scale had flaked off (Fig. 7). A thin, but definite cathodic deposit was noticed on these areas. As the ship stood on the slipway the paint and scale dried and other patches of scale loosened from the hull. These also had a cathodic deposit beneath. This descaling effect was somewhat more noticeable on the port side than on the starboard side. A region about 10 inches wide in way of the anodes was descaled and coated with a layer (about 1/8 inch) of cathodic deposit. (See Figures 8 and 9.)

**Anodes:** The condition of the anodes was rather unexpected. The metal above the copper conductor cast into the anodes was completely eaten away (Figure 8), except under the securing straps on all anodes but two (Figures 9), and the corrosion products remained in the valley that had corroded into the anode surface. This preferential attack was considered to be caused by the molten magnesium partially dissolving the copper rod during the casting operation—as indicated by the reduced diameter of the copper rod. The presence of a copper impurity (0.1 to 0.6 percent) in the anode near the copper rod caused preferential attack in this area, probably by local action on the anode itself. The anodes were still secured to the hull and the electrical circuit was maintained by the contact between intact magnesium and the copper rod under the securing straps. The securing bolts were all in good condition.

It was estimated that if the anodes had not been preferentially attacked they would have lasted at least another nine months, as only 435 lb. out of a total of 800 lb. were consumed. But because of the use of a copper rod in the casting, the anodes would not have lasted much longer—even at this time some of them had almost divided lengthwise.

### Discussion

For a ship that was inactive for five months out of the eleven months elapsed time between drydockings, the area of magnesium used was sufficient for complete protection of the exposed underwater hull. It is probable, from the hull potential readings obtained during April and May 1950, that if the ship had been in continuous active service for the entire period the current output from the anodes would not have been sufficient. There is, however, sufficient evidence to indicate that it is possible and practical to use magnesium anodes to protect completely the underwater area of active ships in sea water. This may be done by a) using a slightly greater anode to hull area ratio; b) using steel rods cast into the anode instead of copper; and c) for hulls coated with standard brands of oil based paints, sandblasting an area in way of the anodes and applying a vinyl paint system up to a distance of 6 to 8 feet from the anodes. The last is in order to decrease the excessive current density in the immediate neighborhood of the anode and thereby give a better overall current distribution. The importance of preventing metallic contact between pro-

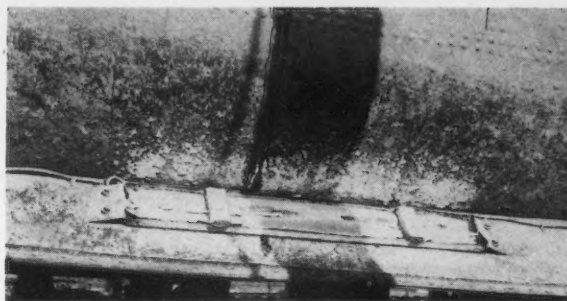


Figure 8—Typical anode showing preferential attack of anode above copper conductor cast in anode. Note cathodic deposit around anode.

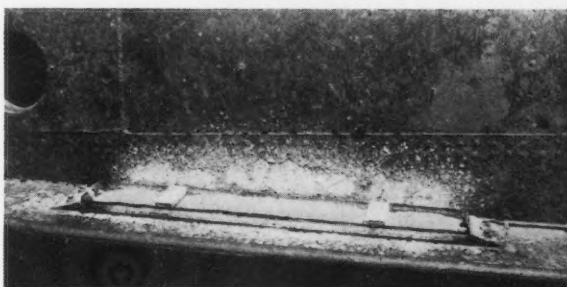


Figure 9—Anode not preferentially attacked—copper-rich region not fully exposed.

tected ships cannot overemphasized and is illustrated several times in Figure 1.

The relatively light amount of fouling observed on the ship is not considered to be the result of cathodic protection but rather the time of year in which the paint was applied. The antifouling paint used is known to have a useful life of somewhat over three months at Halifax. Fouling growth would be prevented during the season when the incidence of fouling is greatest (June to September) and little fouling settlement occurs during the winter months. Thus the ship entered the second summer with a relatively light growth on the hull.

If advantage is taken of the fact that the time of year a ship is painted makes an appreciable difference in fouling growth, and sufficient magnesium anodes are used, it may be possible in East Coast Canadian waters to increase the period between drydockings to two years. The ship will still be protected against corrosion and at the same time would not be seriously fouled.

### Acknowledgments

The work reported here was carried out as part of the program of research of the Naval Research Establishment, Halifax, N.S. Drs. Christie and Greenblatt were associated with the author in this investigation. The author expresses his appreciation for the support which the Defence Research Board of Canada and the Royal Canadian Navy have given to this investigation and for their permission to publish the results.

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# Porcelain Enamel as a Corrosion Resistant Coating for Metals\*

By G. H. McINTYRE

## Introduction

IT IS DOUBTFUL whether anyone has not at one time or another seen and used porcelain enamel finishes for cast iron or steel. Because of its beauty and durability, as well as resistance to corrosion, porcelain or vitreous enamel has been for many years a standard finish on bathtubs, stoves, interiors of refrigerators, washing machines, pots and pans, signs, and many other items where lasting beauty and freedom from corrosion are desired. It is distinguished from organic or paint-type finishes in that it is entirely inorganic in composition and is actually a glass fused (melted) on to the metal base. Its coefficient of expansion is adjusted to match reasonably closely that of the metal base.

Such terms as "glass lined" when applied to chemical ware, hot water, beer, and milk tanks, refer in most instances to porcelain enamel fused to mild steel.

Briefly, the enameling process consists of smelting or reacting at considerably elevated temperatures (2200-2500° F) intimately pulverized and mixed materials such as silica, feldspar, borax, metal fluorides, titanium dioxide or zircon silicate. The resultant molten mass, when bubbling has ceased, is usually discharged from the continuous or batch-type smelter into a tank of water. This sudden chilling of the molten glass produces friable particles known as "frit" and the operation is the "fritting" step. The frit is dried and shipped to the enameling shop in 100-pound paper bags.

Here, the frit is charged into a porcelain-lined ball mill with water and plastic clay and reduced to a fine-particle size. These particles float in the water from the colloidal action of the clay. The colloidal properties are adjusted by the addition of small quantities of electrolytes such as magnesium carbonate, borax, potassium nitrite, epsom salts, or hypo. Small quantities of very plastic clays such as bentonite or montmorillonite are also often used.

The suspension of the finely divided frit (about 95%-200 mesh U. S. Standard Sieve) can be applied to the clean metal base by dipping or spraying. The metal can be cleaned chemically or by blasting. Sheet metal is usually chemically cleaned while castings are usually blasted. No foreign matter should be



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## Abstract

The use of porcelain enamel as a decorative finish is briefly discussed as contrasted to its more recent use as a corrosion resistant coating. The properties of different types of enamels are enumerated as regards methods of application and resistance to acid, weather, water, inorganic salts and other chemicals. Some specific applications for corrosion resistance are discussed which include hot water storage tanks, housings for airplane and tank engine exhaust systems, glass-lined pipe for natural gas containing hydrogen sulfide, chemical process equipment, and street or advertising signs. Resistance to impact damage is also discussed.

present on the metal surface before application of the enamel slip.

After applying the wet enamel in a thin uniform layer, the water is driven off slowly to prevent cracking or flaking of the bisque or unfired coating. The article with the coating cemented by the clay is placed on a conveyor and is brought to a temperature at which the glass particles re-fuse to a homogeneous mass and bonds to the metallic oxide layer formed under the oxidizing conditions. Upon cooling, the glass solidifies and remains bonded to the metal.

For dry-process application the steps are similar but the grinding of the frit is carried out in a dry mill. Clay and electrolytes are not needed. The dry enamel powder is dusted onto a previously heated casting and the whole object reheated to fuse the coating uniformly over the surface.

In coating such large items as chemical reaction vats, beer tanks, and the like, the enamel is fused in exceedingly large furnaces as the entire tank must be brought to a uniform temperature of about 1600° F. The coating is applied by the wet process (usually) through special type spray equipment working inside the previously cleaned tank.

\* Presented at the Fifth Annual Conference and Exhibition, National Association of Corrosion Engineers, April 11-14, 1949, Cincinnati, Ohio.

### Specifications

The question might well be asked as to the type of porcelain enamel for best corrosion resistance. The answer would be that usually this is a compromise between several factors. The type of metal, article to be enameled, and expected usage, have a great bearing on the type of enamel to be selected. For example, an enamel suitable for pressed steel sinks for domestic use would be entirely unsuited to heavy steel chemical vats or as a coating for aluminum shapes. There are no readily available specifications to govern the selection of any enamel for any designated purpose, but there are a wide variety of enamels from which to choose and usually one can be prepared by the supplier to meet most any given set of conditions if certain fundamental factors are considered.

The first of these fundamental factors is resistance to acids and alkalis. The enamels basically are compounds of metal-boro-silicates, titanates, zirconates, or a combination of these. Therefore, porcelain enamels are not resistant to the action of hydrofluoric acid or strong alkalis. In fact hydrofluoric acid, fused caustic, or boiling 8-15 per cent caustic solutions are good agents for the chemical removal of the enamel coating. Color is unimportant.

However, certain types of porcelain enamel can be made more resistant than others and standard tests are available for evaluation of acid resistance.<sup>1</sup> Naturally a greater degree of acid resistance is required for chemical ware than for stove tops or enameled pots and pans. Chemical ware is coated heavily with enamels on a heavy wall thickness metal object that remains in place and which is subjected to pressure and temperature changes as well as highly acid conditions.

Porcelain enamel chemical ware was highly successful in aiding the synthetic rubber program. "Chemical engineers of Goodyear Tire and Rubber Company have given porcelain enamel coatings a

rather wide and versatile usage in their chemical manufacturing and synthetic rubber processes. Porcelain enameled reactors, piping, valves, and fittings are standard equipment for polymerization work in the manufacture of synthetic rubber. Enameled coatings have been found to be far superior to other corrosion-resistant materials.

"Although the primary advantages of porcelain enamel coatings are ease of cleaning and freedom from product contamination, corrosion resistance is highly important. In all instances, the linings have given satisfactory service for latex preparation at pH from 5-10, at temperatures up to 140° F.

"Enameled linings have also proved satisfactory for acid coagulating liquors containing up to two percent sulphuric acid or hydrochloric acid with various concentrations of sodium chloride, various dilute alum solutions, and acetic acid at temperatures up to 175° F.

"Porcelain enamel coatings have been used extensively to protect equipment used in the reaction of dry chlorine gas with aromatic hydrocarbons at temperatures up to 330° F. Hydrogen chloride is evolved from this process and in such reactions any metal or alloy, ferrous or non-ferrous, presents an inhibiting or catalytic action detrimental to the properties of the reaction product. In such cases porcelain enamel is a prerequisite."<sup>2</sup>

Stove tops are usually white and are subjected to surface abrasion and sudden contact with hot grease and boiling water. Pots and pans must be resistant to food acids at boiling temperatures and may be colored or white. Also, they are subject to sudden temperature changes and impact.

A limited conception of the comparative problems involved may be had when these conditions are compared: the correct coefficient of expansion for coating on a heavy metal section would not be suitable for a thin section like a stove top or stew pan. Likewise the radii involved on a stew pan would be much different than on a stove top or a heavy chemical vat.

It might be satisfactory for the surface to show a slight staining or even very slight etch on a chemical vat but this would not do on a stove top.

While porcelain enamels are not satisfactory for resistance to strong alkalis, it is a well known fact that they can be made highly satisfactory for home laundry units where soaps and water softeners may create a weak alkali solution. A quantitative method of evaluation has been suggested by E. Skillicorn and J. E. Hansen.<sup>3</sup> The apparatus used is similar to that employed by the Enameled Utensil Manufacturer's Council and has been adopted as a U. S. Commercial Standard.<sup>4</sup> Typical alkali resistance of various types

TABLE I<sup>2</sup>

Type of Enamel	Enamel	Sample	Weight Loss Grams Sq. In.	Visual Appearance
Alkali Resistant.....	A	1	0.0007	Slight etch
Used as 2nd Coat.....	A	2	0.0012	Slight etch
		Avg.	0.001	
Alkali Resistant.....	A	1	0.0016	Slight etch
Used as overspray.....	A	2	0.0020	Slight etch
		Avg.	0.002	
Alkali Resistant.....	B	1	0.0011	Very slight etch
Used as 2nd Coat.....	B	2	0.0016	Very slight etch
		Avg.	0.001	
Alkali Resistant.....	B	1	0.0030	Very slight etch
Used as overspray.....	B	2	0.0034	Very slight etch
		Avg.	0.003	
Alkali Resistant.....	C	1	0.0025	Etched more than "A"
Ground Coat.....	C	2	0.0027	Etched more than "A"
		Avg.	0.003	
Commercial Black Edge.....	D	1	0.0057	Severe etch—Matte Finish
Overspray.....	D	2	0.0062	Severe etch—Matte Finish
		Avg.	0.006	
Commercial Ground.....	E	1	0.0074	Etched—Matte Finish
Coat.....	E	2	0.0077	Etched—Matte Finish
		Avg.	0.008	
Commercial Black Edge.....	F	1	0.0212	Very severe etch—Matte Finish
Overspray.....	F	2	0.0207	Very severe etch—Matte Finish
		Avg.	0.021	

TABLE II<sup>2</sup>

Type of Enamel	Enamel	Sample	Weight Loss Grams Sq. In.	Visual Appearance
Alkali Resistant.....	A	1	0.008	Smooth etch
Used as 2nd Coat.....	A	2	0.011	Smooth etch
Alkali Resistant.....	B	1	0.007	Test area coated with granular deposit which was washed off leaving gloss only slightly affected.
Used as 2nd Coat.....	B	2	0.006	



of enamels as determined by Skillicorn and Hansen using this test with 5 percent tetra sodium pyrophosphate solution is shown in Table I. The reproducibility of the test appears to be  $\pm 0.0005$ .<sup>3</sup>

Result of the same test on some of the same enamels using 3 percent sodium hydroxide are shown in Table II.

Even though 3 percent sodium hydroxide is approximately equal to 5 percent tetra-sodium-pyrophosphate in available  $\text{Na}_2\text{O}$  or "caustic" content the higher pH (higher active hydroxyl content) of sodium hydroxide makes this more destructive on the porcelain enamel surface.

Another fundamental factor to be considered in selecting an enamel for a designated purpose is resistance to hot water.

Hot water, particularly if under pressure, is one of the most corrosive substances known. It is axiomatic that acid-resisting enamels are not automatically water resistant, but it is also true that all water resistant enamels have some appreciable degree of acid resistance.

Goetchius<sup>5</sup> has published considerable data on enamels, enamel testing and design of porcelain enameled hot water storage tanks and has compared the corrosion resistance of porcelain enamels under various pertinent conditions in relation to other types of metallic coatings. He stated, "The inspection of enameled hot-water tanks which had been in simulated service showed that failure in most cases was caused by localized corrosion with large areas of the tanks still fully protected. This was not surprising, inasmuch as the early technique of enameling tanks had not been perfected. Because the properties of enamel do not favor the formation of electrolytic corrosion cells, these failures must be attributed to the presence of defects in the enamel.

"In spite of these defects, the enameled surface possessed a greater degree of resistance over a wider range of conditions than the galvanized tanks. The control of the water temperature is an important factor in the degree of attack on enameled surfaces; the higher temperatures increased the severity of attack, and steam was particularly corrosive. Only a slight deposition of salts occurred on enameled surfaces and the tank capacity should therefore remain near the maximum throughout the life of the unit. This is not true of the galvanized tanks because heavy salt build-up occurred under all but acid conditions.

"A fairly heavy coating of resistant enamel, free of defects, would probably have a life expectancy far exceeding that of a galvanized surface and would possibly be more adaptable to the extremes of the water conditions in water-tank use.

"The tests indicate that acid-resisting enamels are not necessary for use on hot water tanks. Suitable enamels should have good resistance to frit extraction with hot water and should be unaffected by pressure tests. The chief requirements are good workability and the absence of enamel defects. The mill additions should be made so as to decrease the mill solubility."

Some of Goetchius' data are most interesting in

establishing these statements. In determining solubility in hot water under controlled conditions an average weight loss of three or more enameled samples in a modified Soxhlet extraction apparatus was compared with the weight loss obtained on the frits by water extraction. The data are of interest—See Table III.

A new water resistant but non acid resistant type enamel was developed and tested for six weeks in the weight-loss extractor and compared with the original "A" enamel with results shown in Table IV.

Another factor to be considered in the choice of an enamel is resistance to weathering. Porcelain enamels have been subjected to weathering under many atmospheric conditions both as an article of utility and as controlled tests. Street signs, advertising signs, architectural porcelain enamels of glossy and semi-matte surface structure, acid resisting and non-acid resisting, colored and whites have all been and are being used and tested daily.

Harrison and Moore<sup>6</sup> studied the weather resisting qualities of 864 one-foot-square architectural panels, representing 14 types of enamel and a like number of 4 x 6-inch laboratory specimens. This work was summarized as follows:

"The fact that porcelain enamels can be adapted to a wide variety of specialized uses, by proper adjustments in composition, has as its corollary the fact that careful selection is required to obtain the type of enamel best suited to a given use. That weather-resisting enamels are no exception to this rule is indicated by the following summary of results obtained in a study involving 864 panels, most of which were exposed for a year at one of four locations selected to obtain a variety of climatic and atmospheric conditions.

1. More than half the enamels included in the investigation showed no visible effect after one year of exposure.
2. The acid-resisting enamels were, as a whole, distinctly more durable than the non acid-resisting.
3. The full-matte enamels appeared to be unsuited for architectural use, where appearance is important, because of fading and difficulty in cleaning.
4. Changes in appearance of the surface of the non-acid-resistant colored enamels were, in some instances, noticeable after the first year of weathering. These changes were, in most cases, associated with a pitting of the surface, probably resulting from

TABLE III<sup>5</sup>

Enamel	Avg. Wt. Loss of the Enameled Surface in Grams/Sample (168 Hours)	Total Extraction in Grams from 10 Grams of Frit in 50 cc Water
A—Blue Non: A.R....	0.0029	0.057
B—Opaque: A.R.....	0.0061	0.311
C—Clear: A.R.....	0.0045	0.113

TABLE IV<sup>5</sup>

Enamel.....	Weight Loss in Grams.
E (new).....	0.0342
A (Original Blue Non A.R.).....	0.0445

the presence of acid-forming gases, such as carbon dioxide and sulphur dioxide, in the atmosphere.

5. The formation of these pits on the non-acid-resistant enamels was prevented or inhibited by the application of a thin overglaze of clear, acid-resistant enamel.
6. Weathering was more pronounced at those locations where there is a relatively high concentration of combustion gases and least severe where there is practical absence of these gases in the atmosphere.
7. In all cases where visible effects of weather occurred, the changes were confined to the enamel surface only. In no case was there any failure of the enamel coating to protect the underlying iron from rusting."

These conclusions have been fairly well substantiated by similar test work of Ferro-Enamel laboratories in co-operation with the South Florida Test Service of Miami, Florida. It has been determined that glossy, acid-resistant type enamels are extremely resistant to weathering. Other types of enamels can also be made weather resistant but are not necessarily classed as highly acid resistant.

In 1933 this laboratory concluded on the basis of Weather-O-Meter tests conducted continuously from April 26, 1932, until August 10, 1933, that:

1. All porcelain enamels are extremely resistant to weathering. Compared with the average paint, the life of porcelain enamel should be from ten to twenty times greater.
2. The enamels of the acid resisting and sign (hard surface but not A.R.) type are more resistant than the non-acid-resisting type.
3. Matte finish enamels are resistant to weathering but are subject to stains from foreign substances present in the atmosphere, which stains are exaggerated with increase of degree of mattiness.
4. Corrosive acid gases in the atmosphere will materially lessen the life of the porcelain enamel.

Sweo of the Ferro Enamel Corporation research staff has recently reported on the correlation of weather resistance of porcelain enamel with chemical test data.<sup>7</sup> Sweo concluded that:

1. No correlation exists between weather resistance of porcelain enameled surfaces and resistance to boiling distilled water.
2. No correlation exists between weather resistance and resistance to a boiling 5 percent solution of sodium-pyro-phosphate.
3. Good correlation exists between weather resistance and resistance to a boiling 6 percent solution of citric acid. Enamels which show a weight loss of less than 0.01 gr./sq. inch when subjected to boiling acid test appear to be satisfactory for exterior exposure.

J. C. Hudson and T. A. Banfield studied methods of protecting steel with various non-metallic coatings and made the following statement in regard to porcelain enamel coatings: "As was anticipated, the vitreous (porcelain) enamel has proved markedly resistant to atmospheric attack, and, apart from slight mechanical damage which has chipped the coating on some of them, all the specimens concerned were in perfect condition after five years' exposure"<sup>8</sup> to weathering at special test locations in Sheffield and Calshot, England, and Llanwrtyd Wells, Wales.

Resistance to soil corrosion is another factor to be considered. Porcelain enamels are well known to have excellent resistance to soil corrosion. In general, enamels that are to be in contact with soils should

be of the acid resisting type. It is essential that they be of the highest degree of acid resistance, but as in all other cases where corrosion resistant properties are of importance, the enamel layer should be free of defects such as pinholes or blisters. There should be no break in the continuity of the enamel surface structure.

The large scale adaptation of porcelain enamels to underground pipe lines has been attempted by at least one company. Pipe lines for chemical usage and resistance to corrosion above ground have proven successful as stated earlier in this paper. The burial of such coatings should not make the problem any more serious. Burns and Schuh<sup>9</sup> report that a porcelain enamel finish adapted to resist soil corrosion of both the acid and alkaline types is in good condition after ten years in soil where the life of steel pipe is 1½ to 2 years.

Logan<sup>10</sup> reports that vitreous enamels have been tried experimentally as a protection against soil corrosion and have yielded promising results, but local failures of some of the specimens of one enamel have been recorded.

Other data, as yet unpublished, on specimens exposed for fourteen years burial showed no evidence of rust in any of the soils to which they were exposed. In four of the soils the specimens were pitted but it seemed probable that the pits formed at points where the specimens were injured.

Resistance to heat should also be considered in selecting an enamel. The resistance of all types of porcelain enamel coatings to heat is a well known property. Most porcelain enamel coatings for iron or steel are fused onto the ferrous metal base at temperatures ranging from 1350° to 1600° F. They will not change or soften at temperatures below 1000° F and will last almost indefinitely at temperatures below 1000° F.

Until World War II, there were few applications of porcelain enamel coatings for use above 1000° F, but the shortage of critical nickel and heat-resisting alloys during the war stimulated the development of special types of coatings to resist much higher temperatures as well as sudden changes in temperature.

A classical example was the successful coating of standard low-carbon steel with a thin ceramic material for the exhaust systems of amphibious landing craft and airplane exhaust systems. These types of ceramic enamels were developed at the United States Bureau of Standards and by the laboratories of various frit manufacturers.

Since the war, there is a considerable amount of government sponsored research in the field of ceramic coatings which will be resistant to much higher temperatures than heretofore encountered. These coatings are usually of a matte surface and do not resemble the conventional porcelain enamels in appearance, but are, nevertheless, porcelain enamels of special composition.

The Ferro Enamel Corporation research laboratories developed a special heat resisting coating to be applied to the electric heating elements of electric stoves. Nichrome was not available for this usage. Many thousand units were manufactured from low

carbon steel and a thin ceramic heat resistant coating which under test stood more than 200 hours under constant heat without scaling. The coating was also highly resistant to spalling and scaling when splashed with water or hot grease while under full electrical load.

### Summary

From the discussion it can readily be understood that porcelain enamels for metals cannot be classified by composition nor can broad specifications for general usage be written. Each type of performance must be considered separately and the enamel specified or developed to meet the general set of conditions involved. Such inorganic coatings are available for all types of applications and can be made exceedingly resistant to many types of corrosive forces.

The limiting factors are those of silica or silicates in that there is no resistance to fluorides and hydrofluoric acid or strong caustic solutions. The surface is only as good as its preparation. There must be no defects such as pinholes, or bare metal spots as there is no anodic protection such as is obtained with various metallic-type coatings.

It is not possible to overcome all problems of corrosion by merely specifying that the coatings be of the acid-resistant types. These are usually more difficult to apply and do not necessarily guarantee maximum resistance to corrosion. The design of the article to be coated must be such that it lends itself properly to coatings without warpage and spontaneous damage. Reasonable care must be exercised in handling porcelain enameled articles to prevent damage to the coating but considerable abuse can be tolerated without danger as long as the surface remains intact.

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### DISCUSSION

Questions by R. P. Liesenbom, National Lead Co., Titanium Division, South Amboy, N. J.:

1. What is the resistance of porcelain enamel to the action of moist and dry chlorine at temperatures up to 1000 degrees C?
2. Does a porcelain enamel coating have the usual coefficient of thermal conductivity as given in Perry's Chemical Engineering Handbook?
3. What is the resistance of porcelain enamel to "erosion-corrosion"?
4. Is it possible to apply a porcelain patch to a porcelain coating in the field? If so, what is the technique to be used?

### Author's Reply:

1. Porcelain enamel coatings for metal that are in common use today are not practical as chemically resistant coatings above approximately 500 degrees C. New types of coatings are being developed for protective coatings at excessively high temperatures but these are not of the usual types and there is much to learn yet as to the range of ceramic coatings in the high-temperature field. Normally, acid-resisting types of enamels which are offered commercially for the protection of chemical equipment will withstand chlorine gas and hydrochloric acid for long periods. However, no generalization can be made as each condition requires a special type of enamel.

Interesting data are presented by the Pfaudler Company in a brochure dated May 15, 1944, "Materials of Construction Pfaudler Glasses." This can be obtained by writing to the Pfaudler Company. Much data are offered concerning the specific application of their glasses. Such data should be available from any company furnishing porcelain enamels for corrosion resistance.

2. I refer you to the above-mentioned brochure of the Pfaudler Company. Page 5, Table I on thermal conductivities in BTU per sq. ft. per hr. per 1 in. per 1 degree F is given as 90 at 212 degrees F. This is approximately ten times the value given in the Second Edition of Perry's Handbook, Page 952 where the value is given as 0.5-0.75 and which is expressed as BTU/(hr) (sq. ft.) (°F per ft.).

3. Frankly, I am not in a position to discuss this question in adequate detail. There is very little information available on this "erosion-corrosion" effect but it has been our experience that enamels will withstand severe erosive conditions as witness the enameling of reciprocal pump chambers with good success. The enamel surface is smooth and hard and will withstand many severe erosion conditions without failure. Tests conducted by the Navy Bureau of Ships Laboratories indicate that under high pressure



and velocity some erosion will occur on certain types of enamels. Here again a special type of enamel is required which can be furnished for specific application after a study of the particular problem is made. Formulation of porcelain enamels cannot be generalized as well as organic-type coatings.

4. It is not possible to repair porcelain enamel coatings in the field.

**Comment by F. N. Speller, 6411 Darlington Rd., Pittsburgh 17, Pa.:**

Some tests we conducted over 10 years ago on rate of corrosion in discontinuities in porcelain enamel as applied to exteriors of line pipe, indicated that the rate of penetration slowed down in aerated water and practically stopped after a year. This was evidently due to the electrical insulating property of the enamel and lack of an active cathodic surface.

**Comment by W. F. Deringer, A. O. Smith Corp., Milwaukee, Wis.: on Dr. F. N. Speller's remarks on the effect of discontinuity.**

It has been my experience that porcelain enamel, if it is not continuous, is more likely to permit the coated piece to corrode through than if no coating

were applied. With no coating, the corrosion is general and pitting, if it does occur, does not progress rapidly. If the piece is porcelain enameled but has some small defects (exposed metal) these areas corrode through rapidly. This is the situation if the corroding medium is an aqueous solution and there is an opportunity for galvanic corrosion. I believe that Dr. Speller's observation is correct for situations where galvanic corrosion does not have the opportunity to take place such as would be the case in atmospheric corrosion.

#### Author's Comment:

Referring to Mr. Deringer's comments: Mr. Deringer has had considerable experience in the production of porcelain enameled hot water tanks and large beer vats. It has been his experience that any discontinuity in the surface of a tank which contains hot water under pressure will result in rapid corrosion of the metal at the point of defect in the coating. It is true, as Mr. Deringer states, that there is no galvanic protection from the porcelain enamel coating. I agree with Mr. Deringer that Mr. Speller's observation is correct for situations where galvanic corrosion does not have an opportunity to take place as would be the case in atmospheric corrosion.

## Literature Survey on Corrosion In Neutral Unaerated Oil Well Brines\*

By H. R. COPSON

### Statement of the Problem

THE COMPLEXITY of the problem can be indicated by mentioning some of the variables involved, such as the composition of the water, the water-oil ratio, the wetting power of the oil, the pH of the water at the temperature and pressure in the well, the amount of hydrogen sulfide, carbon dioxide, oxygen, and other gases present, the flow velocity, and the possibility of the formation of protective coatings such as paraffin from the oil or calcium carbonate from the water.<sup>1,2</sup> The problem is further complicated because even in a given well many of these factors may change widely, for instance, the water-oil ratio.

If the well waters were of low pH or if oxygen was present, corrosion of steel equipment would be expected. Many oil well brines, however, are approximately neutral, and it is difficult to see why oxygen should be present. Corrosion under such conditions is an unexplained phenomenon.<sup>3</sup> There has been no satisfactory explanation of why some oil well brines are more corrosive than brines from salt wells,

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or why some sulfide waters are corrosive and others non-corrosive.<sup>4</sup> The importance of oxygen in increasing the corrosion rate of sulfide fluids requires further study.

That down-the-hole corrosion can be serious is amply attested to by photographs of corroded equipment.<sup>5</sup> The chief material involved is steel. In fact, owing to the large tonnages used it is generally felt that any more costly material is out of the question. Generally, corroded equipment is simply replaced

\* A paper prepared for presentation at the Seventh Annual Conference, National Association of Corrosion Engineers, New York, N. Y., March 13-16, 1951.

until the well becomes uneconomic and is abandoned. It has been stated that there are over 400,000 oil wells which average 30 tons of steel per well. Each has one full and one partial string of casing, and in most cases each has a string of tubing and a string of sucker rods.<sup>1</sup> Extra cost might be afforded for special items such as sucker rods, polished rods, well pumps, balls and seats.

The best definition of oil well conditions was made by Rogers and Shellshear.<sup>5</sup> In wells using pumps the flow velocity was between 1 and 5 feet per second. The fluid temperature at the top of the well was between 15.5 and 60 degrees C. The water-to-oil ratio varied from 0 to as high as 50 to 1. The pH of the waters mentioned was between 6.4 and 8.0. In waters which contained hydrogen sulfide there were enough buffers present to keep the pH high. The chief constituents in oil well waters are sodium, calcium, chloride, bicarbonate and sulfide ions and hydrogen sulfide.<sup>6</sup> The low sulfate content of most oil well waters has been attributed to the action of anaerobic bacteria.<sup>7</sup>

Some complicating factors are that attack by hydrogen sulfide may lead to hydrogen embrittlement of steel<sup>8, 9, 10, 11</sup> and that the presence of brine and hydrogen sulfide lowers the resistance to corrosion fatigue.<sup>8</sup> Evidence of sulfide scale may or may not be present. The sulfide scale is cathodic to steel.<sup>8, 12</sup> Generally, the attack tends to be local with deep pitting, and often is not uniform with depth from the surface of the ground.

#### Depolarization

If oxygen is present there is no difficulty in explaining the corrosion. Oxygen is present during drilling operations owing to re-cycling the drilling mud. Oxygen may also be present in producing wells, but in such cases the operator and not nature is said to be at fault.<sup>10</sup> Air gets into the wells by having a vacuum on the producing strata, so that air sucks in during shut-downs. Air may get into the water or gas re-cycling systems. Air contamination is most likely in wells producing only small quantities of fluid daily.<sup>13</sup>

That sulfide brines containing oxygen are very corrosive is attested to by the corrosion of pipe lines and storage tanks handling sour crudes.<sup>1</sup> In pipe lines where water settles out pitting may be of the order of 0.1 ipy. It is interesting that with high flow velocity (4 to 5 feet per second) water cannot settle to bottom of pipe and corrosion is negligible. The corrosion of pipe lines and storage tanks has been extensively studied, the mechanism of the attack is fairly well understood, and remedial measures are at hand.<sup>1</sup>

In their study of corrosion in oil well brines Rogers and Shellshear<sup>5</sup> concluded that under oxygen-free conditions and in the pH range of 6.6 to 8.0, oil well waste waters were non-corrosive regardless of soluble salt or hydrogen sulfide content. Other experimenters have agreed that oxygen must be present for rapid corrosion to occur.<sup>14, 15, 16</sup> Similarly, corrosion by gaseous hydrogen sulfide has been found to be rapid in the presence of oxygen and moisture, but virtually non-existent in the absence of oxygen.<sup>17, 18, 19</sup>

#### Abstract

The causes of oil well subsurface corrosion have never been properly determined. It is known that water must be present, and that most corrosive waters contain hydrogen sulfide, although not all sulfide waters are corrosive. Severe corrosion apparently takes place in some cases in neutral brines in the absence of oxygen. This statement seems paradoxical. To investigate it further, a literature survey was undertaken. The object was to delineate the problems involved and to throw as much light upon them as possible. The literature is discussed particularly with reference to corrosion by hydrogen evolution and by depolarization with oxygen or other agents. Other factors which might enter into the corrosion picture are included in the discussion.

Thus laboratory tests support the contention that some air is necessary for rapid corrosion in neutral brine.

The only possible conclusion from the literature review is either that the observation that corrosion occurs in neutral unaerated brines is incorrect, or else that depolarization is occurring by some other means than through dissolved oxygen. In connection with the former it has been suggested that the pH in the well where corrosion is occurring is lower than that measured after the brine is outside the well,<sup>3</sup> and that oxygen is present more often than realized.<sup>5</sup>

There are other depolarizing agents besides oxygen. In water wells anaerobic corrosion has been caused by nitrates, the nitrates being reduced to nitrites and ammonia.<sup>20</sup> It is extremely unlikely, however, that oxidizing salts are present in oil wells. Carbonates, sulfates, carbon dioxide, or similar compounds containing oxygen will not act as depolarizing agents in neutral solution. In fact, Watts<sup>16</sup> added enough carbon dioxide to brine to lower the pH to 3.9 and still observed no corrosion of steel.

Anaerobic bacteria will cause corrosion of iron if conditions are right. They will depolarize the local cathodes by removing the hydrogen and using it to reduce sulfate to hydrogen sulfide. The requirements are the absence of oxygen, the presence of sulfate, and the presence of assimilable organic compounds and necessary minerals and physiological elements.<sup>21</sup> Such bacteria have been found in oil wells, but generally the bacterial action seems to have gone to completion with all the sulfate having already been reduced.<sup>7</sup> There are other types of bacterial action, and it is possible that some types of anaerobic bacteria may cause corrosion of steel oil well equipment by using cathodic hydrogen to reduce carbon dioxide to methane.<sup>21</sup> Certainly the possibility of corrosion being supported by anaerobic bacteria is a real one.<sup>14</sup>

Some recent British work has shown that a different type of bacterial action can initiate and accelerate corrosion in sea water. This action apparently depends on certain compounds formed by the bacteria. Thus it was shown that cystine can remove hydrogen from local cathodes on iron and be reduced to cysteine.<sup>22</sup> Cystine is an organic disulfide and cysteine is a mercaptan. Similar disulfides and mercaptans are present in crude oil and it is possible that under appropriate conditions they may act as de-

polarizers. The solubility in the water phase would not have to be high. Even if insoluble sufficient turbulence might alternately wet the steel first with water and then with oil, and permit the depolarization reaction to proceed. This would tie in with the notion that the corrosion is related somehow to the sulfur content of the oil.

### Hydrogen Evolution

If the pH of oil well brine was low enough there would be no difficulty accounting for the corrosion. Corrosion would take place by hydrogen evolution. Laboratory tests, however, have indicated that rapid corrosion by hydrogen evolution does not take place at the measured pH values.<sup>23</sup> In the absence of oxygen and with the acidity produced by hydrochloric acid, hydrogen evolution begins at pH 4.2 to 4.5. Since the total acidity as well as the pH is involved, a weak acid will cause hydrogen evolution at a higher pH than a strong acid. With acidity due to carbon dioxide, hydrogen evolution may begin at pH 5.4.

In high pressure gas condensate wells there is sufficient carbon dioxide present to lower the pH to the point where rapid corrosion occurs by hydrogen evolution.<sup>24</sup> The pH at the well head may be as low as 4.0. The corrosion in such cases correlates well with pH and carbon dioxide content.<sup>25</sup> This type of corrosion has been reproduced in the laboratory,<sup>26</sup> although the results have not correlated very well with field experience.<sup>4</sup>

Corrosion in gas condensate wells is a different problem than corrosion in crude-oil waters, but it indicates that the possibility of corrosion by carbon dioxide must be kept in mind. Nevertheless, it appears that generally there is not sufficient carbonic acid in oil well waters to lower the pH to the point where rapid hydrogen evolution occurs. In fact, in some laboratory tests carbon dioxide inhibited corrosion by sulfide brines.<sup>27</sup>

With acidity produced by hydrogen sulfide the situation does not seem much different than with carbon dioxide. In oil well brines<sup>5</sup> hydrogen sulfide accelerated corrosion in the absence of oxygen provided the pH was less than 5.4. Oil well brines are generally sufficiently buffered so that the pH is higher than this. Of course, as has already been pointed out, if oxygen is present sulfide brines become very corrosive. It has been stated that in fields which produce large quantities of hydrogen sulfide bearing brine, there is little or no corrosion irrespective of hydrogen sulfide concentration,<sup>13</sup> the inference being that in such cases oxygen is absent. The effect of hydrogen sulfide on the corrosion of iron by salt solutions was studied by Britton, Hoar, and Evans.<sup>28</sup> Interestingly they found that in citric acid, hydrogen sulfide increased corrosion if the pH was less than 4.0, but decreased corrosion at higher pH.

It has been suggested that galvanic effects might increase the potential on local cells and thus cause hydrogen evolution at a pH higher than that at which evolution would occur naturally.<sup>5</sup> A pH of 6.4 has been referred to as a borderline condition where any driving potential might result in hydrogen evolution. Iron sulfide is quite noble and it has been

suggested that this might provide the driving potential.<sup>8,12</sup>

Opposed to this are the classic experiments of O. P. Watts.<sup>14</sup> Under oxygen free conditions numerous galvanic couples between iron and more noble materials failed to show any corrosion even though in some cases the pH was as low as 3.9. Likewise LaQue<sup>15</sup> reported that there should be no significant galvanic corrosion in oil well fluids under air-free conditions. Where the nickel coating was rubbed off nickel plated sucker rods there was no evidence of galvanic action.<sup>29</sup>

There is always the possibility that the pH down-the-hole where corrosion is occurring is lower than actually measured outside the well where the sample is examined.<sup>3</sup> This might be due to the loss of hydrogen sulfide and carbon dioxide through the release of pressure or to the loss of these constituents through corrosion. The corrosion in water saturated with hydrogen sulfide is said to increase linearly with pressure.<sup>17,19</sup> A difference in pH might be brought about by a difference in temperature, because the ionization of weak acids (propionic acid, for example) increases with temperature.

That considerable hydrogen is found under some conditions is shown by the fact that hydrogen embrittlement of steel equipment has been reported.<sup>3,8,9,10,11</sup> Sucker rods may be brittle as they are pulled and later recover their ductility. Nevertheless, this hydrogen embrittlement may be an accompaniment of corrosion caused by the presence of oxygen. Sulfide corrosion products appear to increase the ease with which hydrogen enters steel.

### Other Factors

While not explaining corrosion in neutral unaerated brines, there are a number of other factors which enter into the corrosion picture and which should be considered. One of these is the wetting power of oil or the ability of oil to replace water at the steel surface.<sup>30</sup> This may be the distinguishing feature between corrosive and non-corrosive brines. Of course, the water-to-oil ratio is important also. If the steel is covered with oil corrosion is low. Wetting agents have been used commercially to develop oil films and reduce corrosion. An interesting thought is the possibility that alloy steels or other materials might be wet more readily by oil than plain steel.

Another factor is the flow velocity and erosive and impingement effects. Rogers<sup>30</sup> found that erosion at couplings removed the protective oil film and permitted water to wet the pipe. LaQue<sup>15</sup> mentioned that erosion is necessary in condensate wells to have rapid corrosion. Presumably this is due to removal of protective films of corrosion products. Erosive and impingement effects could easily explain localization of the attack.

Another factor is the stress present. According to Eilerts<sup>31</sup> stress triples the corrosion of steel in carbonic acid at 200 psi and 130 F. Such effects of stress generally occur in acid solutions and not in neutral solutions. Stress could disrupt protective films and cause localization of the attack. Stress has been said



to increase the rate of hydrogen embrittlement by hydrogen sulfide.<sup>8,32</sup> Both the localization of the attack and the embrittlement would accelerate corrosion fatigue failures.

Corrosion fatigue of oil well equipment was recently discussed by Morton.<sup>3</sup> Corrosion fatigue failures are not always readily distinguished from pure fatigue failures, and, of course, there are plenty of reasons for fatigue failures in oil wells. Test data indicate that nickel steels are particularly resistant to fatigue in sulfide brines.<sup>33,34,35,36,37</sup> This may be a matter of pit depth and pit shape. In both the atmosphere<sup>38,39</sup> and in soils<sup>40</sup> nickel steels have been found to develop comparatively shallow pits. Similar behavior in oil wells would explain their superior resistance to corrosion fatigue.

Inhibitors have been found to decrease attack in corrosive wells. Formaldehyde seems quite popular.<sup>8,12,27,41</sup> The formaldehyde is injected daily into the annulus between the tubing and casing, care being exercised to exclude air. The formaldehyde is thought to react with sulfides in well fluids and the product to form a protective film on the equipment. Its inhibiting efficiency decreases with temperature, and it is ineffective in wells with high bottom hole temperature. It should be remarked that formaldehyde is a bactericide and that it would prevent corrosion by anaerobic bacteria.<sup>42</sup>

Other inhibitors have been suggested but their merit seems to be in dispute. Among these are hexametaphosphate with tannin, sodium chromate, or zinc chromate,<sup>6</sup> caustic soda and tannic acid,<sup>6</sup> sulfonated fatty acids and ammonia,<sup>43</sup> and alkali treatments.<sup>44</sup> The use of wetting agents have already been mentioned.<sup>40</sup> Oil soluble surface active agents seem to belong to this class.<sup>45,46</sup>

### Discussion

The literature survey shows that oil well subsurface corrosion is a complex problem with many variables. Laboratory experiments have thrown some light on the problem, but have not explained the mechanism of corrosion in neutral unaerated brines. A major program of further investigation is required.

Recently the NACE Technical Practices Committee, TP-1, broadened its scope to include a study of corrosion in oil well equipment. This seems like a good move, and should have the advantage of close touch with field conditions. It is expected that interesting results will be forthcoming from the studies of this committee.

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## Addendum:

# Corrosion Problems in the Modern By-Product Coke Plant\*

By E. A. TICE\*

Since the time of presentation of this paper\* at the 1950 conference, the writer has had the opportunity to conduct more spool tests in operating coke by-product plant equipment. The results of these tests further substantiate the results shown in the paper, and may be of added interest to by-Product plant operators.

In Table A are shown the results of three tests installed in a typical ammonia still. These results indicate the useable low corrosion rate of mild carbon steel, and the susceptibility to pitting attack of the stainless steels, Monel, nickel and Inconel. As would be expected Monel and nickel were very badly attacked in the wet ammonia vapor phase at the top of the still (Spool 3).

TABLE A

Test in a Typical Ammonia Still  
Test Duration: 144 days.  
Spool 1—At bottom of Fixed Still.  
Spool 2—At bottom of Free Leg.  
Spool 3—At top of Free Leg in Ammonia Vapor Line.

MATERIAL	CORROSION RATES—INCHES PER YEAR		
	Spool 1	Spool 2	Spool 3
Inconel.....	<0.0001 <sup>a</sup>	<0.0001	0.0001
Type 316 Stainless.....	<0.0001 <sup>b</sup>	<0.0001 <sup>a</sup>	<0.0001
Type 304 Stainless.....	<0.0001 <sup>c</sup>	<0.0001 <sup>a</sup>	<0.0001
Type 430 Stainless.....	0.001	<0.0001 <sup>b</sup>	<0.0001 <sup>a</sup>
Type 410 Stainless.....	0.002 <sup>d</sup>	<0.0001 <sup>b</sup>	<0.0001 <sup>a</sup>
Monel.....	0.004 <sup>e</sup>	0.0005	>0.040 <sup>g</sup>
Nickel.....	0.0006 <sup>e</sup>	0.0006	>0.040 <sup>g</sup>
Ni-Resist III.....	0.001	<0.0001	0.022
Mild Steel.....	0.009	0.001	0.005

- <sup>a</sup> Scattered pits to a depth of 0.002" during test.
- <sup>b</sup> General pitting to a depth of 0.008" during test.
- <sup>c</sup> General pitting to a depth of 0.012" during test.
- <sup>d</sup> Severe crevice corrosion under insulating spacer.
- <sup>e</sup> Broad pits, to a depth of 0.015" during test.
- <sup>g</sup> Specimens completely corroded away during test.

In connection with light oil acid washing more data have been accumulated in the process wherein water dilution of the acid is employed. (See Figure 12 in the paper). Test spools were installed at three locations in a 10,000 gallon lead lined washer as in-

dicated in Table B. During a 40-day test period, 69 charges were processed, and the results were as follows:

TABLE B

Spool 1—Installed in cone bottom.  
Spool 2—Installed three feet below liquid level, just below agitator impeller.  
Spool 3—Installed above liquid level in top of unit, subjected to splashing.

MATERIAL	CORROSION RATES—INCHES PER YEAR		
	Spool 1	Spool 2	Spool 3
Chemical Lead.....	0.009	0.009	0.003
Antimonial Lead.....	0.010	0.008	0.002
Tellurium Lead.....	0.010	0.009	0.005
Carpenter 20.....	0.017	0.012	0.002
Monel.....	0.026	0.021	0.017
10 percent Al Bronze.....	0.032	0.029	0.021
Silicon Bronze.....	0.033	0.032	0.027
Type 304 Stainless.....	0.073	0.020	0.077
Type 316 Stainless.....	0.090	0.087	0.015
Inconel.....	0.087	0.078	0.033
Nickel.....	>0.14 <sup>a</sup>	0.093	0.070
Type 430 Stainless.....	>0.14 <sup>a</sup>	>0.14 <sup>a</sup>	0.102
Killed Steel.....	0.22	0.16	0.082
Type III Ni-Resist.....	0.22	0.17	0.013
Gray Cast Iron.....	0.38	0.36	Not Tested

\* Specimens originally 0.031" thick were completely corroded away during test.

These results indicate the superior corrosion resistance of lead in this application. However, lead linings in this plant have required considerable maintenance due to the rather poor mechanical properties of lead. Of the other materials tested only four appear to have merit corrosion wise, namely: Carpenter 20, Monel, 10 percent aluminum bronze, and silicon bronze. These all show moderately high corrosion rates, however, and if any were to be employed, the unit would have to be designed thick enough to allow for corrosion losses of the order shown. For example, for a 10 year expected life, the design would have to allow for corrosion losses of the order of 0.2 to 0.3 inches. Whether or not such alloys might be economical for the shell of the washer could only be determined by comparing the present maintenance costs with the cost of the alloys when employed thick enough to allow these corrosion losses.

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\* Corrosion Engineering Section, The International Nickel Co., Inc., New York, N.Y.



# Corrosion Resistant Equipment For the Corn Refining Industry\*

By R. W. FLOURNOY\*

**C**ORROSIVE ENVIRONMENTS exist in the corn refining industry because of certain materials used in the process. The use of sulfur dioxide and sulfurous acid in the steeping of corn and during the wet milling and separation processes causes some severe corrosion problems. Hydrochloric or sulfuric acids in dilute solutions are used for the hydrolysis of starch slurries to produce corn syrup and dextrose. Acid and chemically modified starch or dextrine are produced using agents which are often corrosive to equipment. Corn oil fatty acids are responsible for corrosion of some equipment used for processing and refining corn oil. The various process steps and some of the corrosive environments of the corn refining industry are shown in the simple process flow sheet in Figure 1. Seven typical corrosion environments were selected from this flow sheet for the presentation of corrosion data.

Corrosion data shown in Tables I through VIII were taken from laboratory and field corrosion tests. Metal and alloy test pieces, carefully prepared and accurately weighed were exposed to test conditions in locations selected to give representative corrosion data. Test assemblies were insulated (electrically) from the equipment and were also individually insulated. After exposure to a corrosion environment, the test pieces were carefully cleaned and reweighed to determine their weight losses. In the case of pitting, examination of the test piece with a metallurgical microscope was used to determine maximum pitting depth. Corrosion rates (uniform) were calculated from the weight loss, exposed area, and test period. A corrosion cost index was calculated from the corrosion rate and base cost of the material tested. The

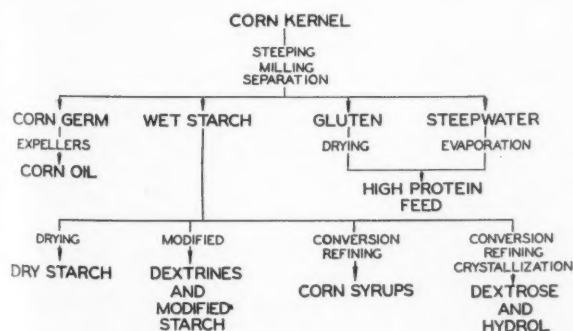


Figure 1—Corn refining process flow sheet.

## Abstract

A general process flow sheet of the corn refining industry is shown to indicate the process steps for which corrosion data were determined. Corrosion data for starch, dextrose and by-product manufacture were taken from field and laboratory corrosion tests. Special techniques for determining the effect of pitting, intergranular corrosion of welds and applied stress were used for some materials tested. Determination of metallic contamination by a corrosion test is explained. The inclusion of economic factors in calculation of a corrosion cost index was employed in evaluating the corrosion data.

Corrosion rates and corrosion cost index values are shown in tables for a number of process steps in the corn refining industry. The materials which indicated satisfactory values are separated from the materials which did not indicate satisfactory service in the environment. The corrosion data are confirmed in some tests by actual experiences with plant equipment. Limiting values for corrosion rates and corrosion cost index are shown.

The corrosion data are summarized to show the materials which may be considered corrosion resistant for certain corn refining processes. The materials are shown in the order of preference. Factors of physical characteristics and availability are shown for some materials.

corrosion rates shown in the data are expressed in mils penetration (average) per year and the corrosion cost index which is the cost of material corroded away is expressed in dollars per square foot per year. The following equations were used to calculate corrosion rates and corrosion cost index values for materials with specific gravity 8.0, for materials of other specific gravity a correction factor must be used.

## Equations for Calculation of Corrosion Rate and Corrosion Cost Index Values

### Corrosion Rate

$$Mpy = \frac{WL \times 68,500}{A \times H}$$

Mpy = Uniform corrosion rate in mils penetration per year.

WL = Weight loss in grams.

A = Total exposed area in square inches.

H = Total test time in hours.

This equation is for use with materials of specific gravity 7.5-8.5, for other values of specific gravity a conversion factor must be used.

### Corrosion Cost Index

$$C.C.I. = Mpy \times BC \times 0.0416$$

C.C.I. = Corrosion cost index in dollars per square foot per year.

BC = Base cost of material in dollars per pound.

Mpy = Corrosion rate in mils per year for metals with specific gravity 7.5-8.5.

\*A paper presented at the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

\* Chemical Division, Corn Products Refining Co., Argo, Ill.

Corrosion rates less than 3.0 mils per year are usually considered satisfactory for materials of construction. A corrosion cost index greater than ten cents per square foot per year is considered excessive. In order for a material to be considered satisfactory its corrosion rate and corrosion cost index must both fall below the arbitrary limits stated. Materials which indicate high pitting rates are not considered satisfactory for heat exchanger tubes or thin walled equipment although the materials may be satisfactory for thick castings or sections.

Since equipment may fail by pitting, intergranular attack of heated zones, influence of bimetallic couples, stress corrosion cracking or other localized corrosion attack, special tests were used to predict such failures. The test pieces shown in Figure II were used whenever localized corrosion attack was considered possible in a given environment. Corrosion test pieces of two metals or alloys were coupled to produce a bimetallic couple which was exposed to test conditions simultaneously with insulated test pieces of the two materials. If the ratio of corrosion rates for the materials in the bimetallic couple was appreciably different from the ratio of the corrosion rates of the insulated test pieces, the bimetallic couple was considered to accelerate corrosion of the anode. This was also verified by electrical measurement of maximum current flow in a metallic couple of electrodes immersed in the liquor environment. Although data are not available for all environments, the bimetallic couples iron-copper and iron-stainless steel (Types 316 and 304) were found to be poor construction particularly in the evaporation of steepwater and in acidified starch slurries under plant conditions.

Intergranular attack of weld zones and heat affected stainless steels Types 316 and 304 was predicted by testing commercially annealed test pieces (with exposed electric welds) and sensitized test pieces simultaneously. Sensitized test pieces were prepared by heating the stainless steel alloy at 1200° F for six hours and cooling it slowly in the furnace. If the sensitized test piece indicated an appreciably greater corrosion rate than that of the

**TABLE I**  
**Corrosion of Annealed and Sensitized Stainless Steel Alloys**

Corrosion Environment	Corrosion Rate—Mils/Year		
	Stainless 316		Stainless 304
Sulfur burner gases at 400° F., 584 hours time.....	70.9	(A)	44.5
Sulfur dioxide liquor 0.3 percent SO <sub>2</sub> , 130° F., 584 hours time.....	37.7	(S)	39.6
Vapor from SO <sub>2</sub> tower, 0.14 percent SO <sub>2</sub> , 120° F., 584 hours time.....	0.13	(A)	0.18
Corn steepwater, 3.5° Be, pH 4.0, 105° F., 591 hours time.....	0.64	(S)	1.27
Corn steepwater, 3.5° Be, pH 2.0, 105° F., 591 hours time.....	18.2	(A)	215.4
Corn oil fatty acids, 190° F., 2856 hours time.....	214.9	(S)	209.3
Fatty acid and sulfuric acid (1-5 percent), 120° F., 2736 hours time.....	0.08	(A)	0.06
Dextrose remelt liquor, pH 4.0, 155° F., 2496 hours time.....	0.22	(S)	0.25
	0.07	(A)	0.11
	3.98	(S)	4.77
	1.01	(A)	4.19
	8.06	(S)	9.66
	0.13	(A)	2.16
	3.65	(S)	3.82
	0.07	(A)	0.20
	0.45	(S)	0.39

**TABLE II**  
**Field Corrosion Test—Sulfur Dioxide Absorption Tower**  
Environment. Sulfur dioxide and water vapor, saturated at 90° F. and atmospheric pressure. 496 hours test time.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils/Year
Stainless No. 20.....	0.11	1.64
Stainless 317.....	0.45	15.3
Stainless 318.....	0.83	24.9
Stainless 316.....	0.74	29.6
Stainless 310.....	2.95	108.9
Stainless 304.....	2.84	151.7

annealed test piece (and above the arbitrary limit), equipment used in the environment should be fabricated from alloy of 0.03 percent carbon maximum, alloy stabilized by the required columbium content or equipment fully annealed by heat treatment after fabrication (if feasible). In some environments, neither the annealed nor sensitized test pieces indicated satisfactory corrosion rates and the alloy could not be recommended for use in this case. Whenever the sensitized and annealed test pieces indicated similar corrosion rates, both below the arbitrary limit, the welded equipment would not require annealing after fabrication, extra low carbon content or stabilized alloy analyses. Typical tests of sensitized and annealed stainless steel test pieces are shown in Table I.

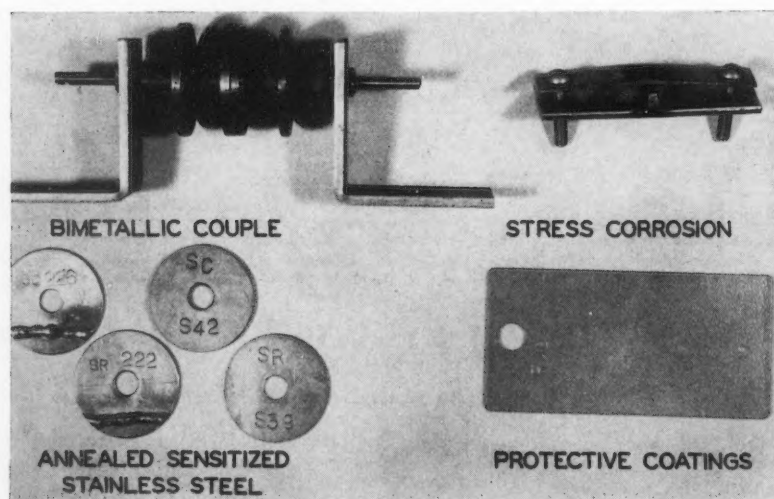


Figure 2—Special corrosion test assemblies.

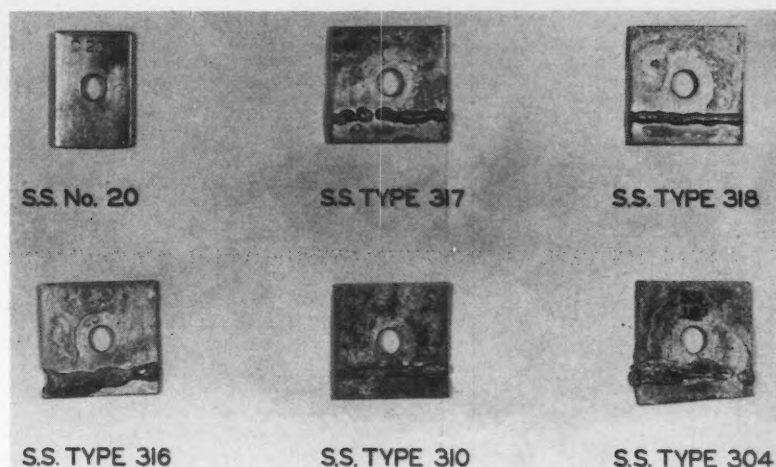


Figure 3—Corrosion test—SO<sub>2</sub> absorption tower.

A stress-corrosion test piece is shown in Figure 2. A welded metal strip was stressed slightly beyond the yield point and exposed to test. Although none of the environments tested indicated severe stress-corrosion cracking of stainless steels Types 316 and 304, the corrosion rate of the stressed test piece was usually several times greater than that of the unstressed test piece.

Protective coating test pieces were subjected to tests in the severe conditions of moisture, sulfur dioxide and sulfurous acid which exist in the wet milling equipment. It is not the purpose of this paper to differentiate between types and brands of protective coatings. The tests have indicated the importance of surface preparation, low permeability of the coating to moisture and sulfur dioxide and other factors in coating application.

It is possible to calculate a value for metallic contamination of liquors in which metals and alloys have been exposed. The weight loss of the metal test piece and the weight of the liquor used for testing are used to calculate a value of metallic contamination for a given test time. The calculated value agrees fairly well with the value obtained by chemical analysis of the liquor. Usually the calculated value is the maximum for the value obtained by analysis.

In many corrosion tests it is essential to test materials in certain physical forms or with dimension limitations. In Tables 6A and 6B the test pieces were all alloy cast pieces since castings make up the large portion or all of the components used in batch dextrose converters. In testing hardened (by heat treatment) materials it is essential to retain the actual dimensions of the material in service since hardened case depth and other properties are dependent on these dimensions.

Corrosion data for seven typical plant environments are shown in Tables II to VIII inclusive

### Summary and Conclusions

#### Sulfur Dioxide Absorption Tower

A wrought stainless Number 20 alloy was the only alloy tested which indicated satisfactory service

TABLE III  
Laboratory Corrosion Test—Filtrates from Rotary Starch Filters  
Environment. Liquid phase, pH 3.5 (sulfur dioxide) at 125° F., agitated and open to the atmosphere. 1060 hours test time.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils/Year
Stainless 316.....	0.00	0.05
Stainless 318.....	0.00	0.05
Stainless 317.....	0.00	0.07
13 percent Chrome; 80 percent Nickel*.....	0.04	0.99
Copper.....	0.03	2.36
10 percent Cupro Nickel.....	0.04	2.53
30 percent Cupro Nickel.....	0.06	3.00

\* Maximum crevice pitting 17.6 mils in 1060 hours.

TABLE IV  
Field Corrosion Test—Gluten Slurry Blender  
Environment. Liquid phase, 18-20 ounces of gluten per gallon of slurry, 80°-90° F., pH 3.8-4.0, acidity as SO<sub>2</sub> 0.09-0.12 percent agitated. 569 hours test time.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils/Year
Stainless 317.....	0.00	0.03
Stainless 310.....	0.00	0.03
Stainless 304.....	0.00	0.03
Stainless 347.....	0.00	0.11
Aluminum.....	0.04	0.34
Stainless 446*.....	0.00	0.24
Copper.....	0.01	0.62
Yellow Brass.....	0.01	0.66
Silicon Bronze.....	0.01	0.82
Aluminum Bronze.....	0.02	0.87
67 percent Nickel; 30 percent Copper.....	0.04	1.43
Mild Steel†.....	0.11	36.3

\* Maximum pitting 3.6 mils in 569 hours.

† Maximum pitting 7.2 mils in 569 hours.

in this sulfurous acid atmosphere. Wood, acidproof brick and stoneware are used in plant practice.

#### Filtrates from Rotary Starch Filters

Stainless steel Types 317, 318 and 316 indicated satisfactory service for starch wash filtrates. Stainless steel Type 304 failed in service as a filter bed after approximately six months service. Crevice type pitting was the primary cause of failure in this material.

#### Gluten Slurry Blender

Stainless steel Types 317, 310, 304, 347, aluminum (commercial purity), copper, yellow brass (70 copper, 30 zinc), silicon bronze and aluminum bronze indicated satisfactory service for gluten slurry. Stain-



TABLE V-A

## Field Corrosion Test—Steepwater Evaporators

Environment. Liquid phase, 4°-10° Baume' steepwater, pH 4.0, 150°-190° F., agitated. 5800 hours test time. First effect.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
Stainless 316.....	0.00	0.02
Stainless 317.....	0.00	0.02
Stainless 310.....	0.00	0.15
Stainless 347.....	0.01	0.35
Stainless 304.....	0.01	0.45
Stainless 446.....	0.25	16.77
Yellow Brass.....	0.25	20.17
Silicon Bronze.....	0.34	20.98
Copper.....	0.35	24.45
10 percent Cupro Nickel.....	0.38	22.81
30 percent Cupro Nickel.....	0.44	21.44
Aluminum Bronze.....	0.53	21.04
65 percent Nickel; 30 percent Copper.....	0.77	24.82
Mild Steel.....	0.17	59.26
Cast Iron.....	0.42	101.8

TABLE V-B

## Field Corrosion Test—Steepwater Evaporators

Environment. Liquid phase, 6°-15° Baume' steepwater, pH 4.0, 150°-190° F., agitated. 5800 hours test time. Third effect.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
Stainless 304.....	0.00	0.01
Stainless 316.....	0.00	0.01
Stainless 317.....	0.00	0.02
Stainless 310.....	0.00	0.02
Stainless 347.....	0.00	0.04
Stainless 446.....	0.00	0.17
Yellow Brass.....	0.19	15.16
Silicon Bronze.....	0.21	12.86
Copper.....	0.22	15.31
10 percent Cupro Nickel.....	0.23	13.75
30 percent Cupro Nickel.....	0.28	13.50
65 percent Nickel; 30 percent Copper.....	0.36	11.50
Aluminum Bronze.....	0.41	16.28
Mild Steel.....	0.14	48.01
Cast Iron.....	0.44	105.13

less steel Type 316 and aluminum bronze have given satisfactory service as bowls in gluten slurry centrifuges. Rubber and ceramic lined valves used for throttling of gluten slurry failed in less than a month of service due to loss of the lining by erosion.

## Steepwater Evaporators

Stainless steel Types 317, 316, 310, 304 and 347 indicated satisfactory service for steepwater evaporators. In plant practice, cast iron evaporator shells fail in two to five years of operation. Copper tubes in evaporators last between two and five years. Seamless stainless steel Type 304 tubes last between five and ten years but welded tubes give much shorter life. Welded stainless steel Type 316 tubes have been in service for two years with no indications of failure. Stainless steel Type 316 linings and tube sheets have given excellent service to date.

## Dextrose Converters

Cast stainless steels designated A7M and 18-10M by their manufacturers, and several alloys high in chrome nickel and molybdenum indicated satisfactory service (with exceptions for crevice type pitting) for the liquid and vapor phase of dextrose converters. Valves and pumps made from these alloys have shown good service life. A Ni-Resist valve (body) with stainless steel Type 316 seating surfaces has been in service on a dextrose converter liquor inlet for seventeen months with no evidence of corrosion. Acid resistant bronze and aluminum

TABLE VI-A

## Field Corrosion Test—Dextrose Converter

Environment. 10.0° Baume' starch slurry acidified to 0.02 Normal with hydrochloric acid, pH 1.8, converted at 275° F., agitated. Cast alloy test pieces. 3220-5220 hours test time.

## VAPOR PHASE

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
Stainless (18-10 Mo).....	0.00	0.15
60 Ni, 18 Mo, 18 Cr.....	0.01	0.11
Stainless No. 20*.....	0.01	0.13
Stainless (A7M)*.....	0.01	0.23
Fe, 24 Ni, 20 Cr, 3 Si, 3 Mo.....	0.03	0.50
Ni, 28 Mo, 5 Fe.....	0.10	1.10
67 percent Nickel; 30 percent Copper.....	0.07	2.95
14 percent Silicon Iron.....	0.09	1.97
18 percent Nickel Cast Iron.....	0.17	20.9
18 percent Nickel Cast Iron.....	0.20	18.9
Silicon Bronze.....	0.27	16.2
Lead Bronze.....	0.35	13.5
Acid Resistant Bronze.....	0.37	13.8
Aluminum Bronze.....	0.46	17.1
Aluminum Bronze.....	0.59	21.7
Cast Iron.....	0.35	94.7

\* Maximum crevice pitting 4.6 mils in 5220 hours.

† Maximum crevice pitting 5.7 mils in 5220 hours.

TABLE VI-B

## Field Corrosion Test—Dextrose Converter

Environment. 10° Baume' starch slurry acidified to 0.02 Normal with hydrochloric acid, pH 1.8, converted at 275° F., agitated. Cast alloy test pieces. 3220-5220 hours test time.

## LIQUID PHASE

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
60 Ni, 18 Mo, 18 Cr.....	0.01	0.09
Stainless (18-10 Mo)*.....	0.01	0.41
Stainless No. 20*.....	0.05	0.82
Stainless A7M*.....	0.02	1.03
14 percent Silicon Iron.....	0.12	2.59
Fe, 24 Ni, 20 Cr, 3 Si, 3 Mo.....	0.16	2.50
Ni, 28 Mo, 5 Fe.....	0.20	2.32
Si—Mo Iron.....	0.27	4.38
67 percent Nickel; 30 percent Copper.....	0.19	7.65
18 percent Nickel Cast Iron.....	0.20	24.5
Silicon Bronze.....	0.25	14.8
18 percent Nickel Cast Iron.....	0.25	23.8
Acid Resistant Bronze.....	0.41	15.1
Aluminum Bronze.....	0.41	15.3
Aluminum Bronze.....	0.58	21.3
Lead Bronze.....	0.58	21.6
Cast Iron.....	0.52	138.0

\* Maximum crevice pitting rate varied.  
3.0—10.0 mils in 5220 hours.

bronze valves give fair service in converter lines but are not as satisfactory as some of the high chrome, nickel, molybdenum alloys. Gate valves with stainless steel Type 316 seating surfaces cannot be operated under converter pressures. Galling of the seating surfaces leads to early failures.

## Ion-Exchanged Corn Syrup Liquors

Stainless steel Types 317, 316, 304 and aluminum bronze indicated satisfactory corrosion resistance to this environment. Cast iron body valves fail in a few months service in this environment.

## Feed Drier Vapor Duct

Stainless steel Types 318 and 316 (0.03 percent carbon maximum) were the only materials tested which indicated satisfactory service life for this drier duct. Cast iron sections show rapid corrosion within a few years' time. Wood ducts are satisfactory as long as they are not destroyed by fires. Ebony Transite is still in service on one drier after five years operation but this material is no longer available.

TABLE VII-A

## Field Corrosion Test—Ion-Exchanged Corn Syrup Liquors

Environment: Liquid phase, 18° Baume' ion-exchanged corn syrup, pH 5.0-6.0 120°-130° F., agitated. 238 hours test time.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
Stainless 304.....	0.00	0.03
Stainless 310.....	0.00	0.09
Aluminum Bronze.....	0.00	0.15
Stainless 317.....	0.01	0.18
Stainless 446.....	0.01	0.35
Aluminum.....	0.01	0.97
Copper.....	0.05	3.41
Silicon Bronze.....	0.08	4.74
Yellow Brass.....	0.08	6.18
65 percent Nickel; 30 percent Copper.....	0.22	6.92
Mild Steel.....	0.21	71.7

TABLE VIII

## Field Corrosion Test—Feed Drier Vapor Duct

Environment: Moisture, sulfur dioxide, carbon dioxide, lactic acid and organic acid vapors, 200° F.-400° F., 6500 hours test time.

MATERIAL	Corrosion Cost Index \$/Sq. Ft./Year	Corrosion Rate Mils./Year
Stainless 316*.....	0.00	0.11
(Carbon 0.03 percent)		
Stainless 316*.....	0.01	0.20
Stainless 316*.....	0.01	0.22
Stainless 347†.....	0.06	2.70
Stainless 329.....	0.08	5.05
Stainless 304†.....	0.33	20.5
67 percent Nickel; 30 percent Copper.....	0.36	23.7
Aluminum.....	0.56	35.0
Cast Iron.....	0.19	46.5

\* Maximum pitting 5.0—16.0 mils in 6500 hours.

† Maximum pitting 6.0—15.0 mils in 6500 hours.

## Limitations of Materials

1. Some castings such as silicon iron are not machinable, available only in certain forms, easily fractured.
2. Stainless steel Types 316 parts in contact under pressure are subject to galling and not suitable for valve seating surfaces, pump rods or shafts.
3. Soft materials are not satisfactory for valve seating surfaces subject to erosion and corrosion.

Stellite-faced seating surfaces usually solve this problem.

4. All of the available corrosion resistant materials are not machinable, sizes available are usually limited.
5. Temperature limitations are low for plastics, hard rubber and many stainless steel alloys are sensitive to temperatures as low as 800° F.
6. Although the average corrosion rate for a material is satisfactory, it cannot be used for heat exchanger tubes or thin walled equipment if pitting is indicated to be a problem.

## DISCUSSION

Questions by E. H. Wyche, Lukens Steel Co., Coatesville, Pa.:

Have you noticed any appreciable difference in the corrosion behavior of Type 316 Stainless versus Type 317 Stainless in wrought forms?

Also, any difference in behavior of 0.03 max carbon 316 compared to 318?

## Author's Reply:

The corrosion data in Table I indicate the usual superiority of stainless steel Type 317 over stainless steel Type 316. In this severe corrosion environment stainless steel Type 316 shows a corrosion rate (29.6 mils per year) approximately double the corrosion rate (15.3 mils per year) for stainless Type 317.

Corrosion data in Table VII include corrosion rates for stainless steel Type 316 (0.03 percent carbon) and stainless Type 316 (0.10 percent carbon maximum). The extra low carbon alloy was slightly superior in corrosion resistance, i.e., 0.11 mils per year versus 0.22 mils per year. Stainless Type 318 tested at a later date and for a shorter period of time indicated a corrosion rate of 0.10 mils per year with less tendency for pitting than shown by Type 316 (0.03 percent carbon).

# Tower Footing Corrosion\*

By WALTER J. PIPER and JOHN D. PIPER

## Introduction

THE DETROIT EDISON COMPANY has approximately 400 miles of 120-kv aerial transmission power lines which connect ten widely separated switching stations. The lines distribute power in the thumb area and southeastern region of Michigan.

The power lines are supported 65 to 90 feet above ground on approximately 3200 galvanized structural steel towers of several different types. Consecutive towers are connected by an overhead wire which is grounded at the switching stations. The minimum weight of zinc specified for the original galvanized coating on these towers was two ounces per square foot. At bi-yearly intervals the towers are climbed and subjected to routine inspection by patrol line-men of the Overhead Lines Department. These inspections include noting the condition of the galvanizing on the above-ground members.

In 1936, after the towers had been in service for a period of from 7 to 13 years, the company decided to investigate whether any significant corrosion was occurring on the underground members of the towers in addition to the portion above ground. This study consisted of two parts:

- (1) A visual examination of the condition of the galvanizing on the tower members above the ground level, at the ground level, and below ground to a depth of three feet for approximately 30 towers at selected locations representing various types of soil.
- (2) Determination of the average thickness of the galvanizing on a replaceable tower member assumed to be representative of average conditions in the locations examined.

The results of these studies, which were published previously,<sup>1</sup> indicated that nearly all the towers were in good condition. Significant corrosion was found in only a few places, mostly where the underground portion of the tower was situated in heavy muck soil.

It was realized that the method used by these observers had several limitations, namely: 1) the 30 towers examined could not be considered to represent the 3200 towers in the system; 2) the limited underground portion of the tower examined might not indicate the condition of the entire leg and footing; 3) the removing of an entire leg for a more complete examination would be very costly and time-consuming.

In 1946 R. L. Featherly and H.A. Robinson of Dow Chemical Company reported to the authors and their colleagues that a brief survey of the extent of corrosion on the underground portions of towers had been made in California. The method involved mak-

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JOHN D. PIPER—Chemical Supervisor, Research Department, The Detroit Edison Co., is a graduate of Michigan State Normal College with an AB in 1929 and holds MSc and PhD degrees from Ohio State University. His principal fields of research are dielectrics, high voltage cables, fireside deposits in steam generators and corrosion of steel tower footings.



ing electropotential measurements to determine the difference in potential between the tower and a copper-copper-sulfate reference electrode. By private communication, P. H. Yelton of California Electric Power Company and R. L. Featherly reported that P. H. Yelton and W. T. Johnson of California Electric Power Company and H. P. Atkin of Dow Chemical Company had measured the potentials of several towers before and after magnesium anodes were installed. They showed that the original potential between the tower and the reference electrode varied from 0.275 to 0.643 volt for 14 towers tested. These 14 towers were located on four different lines and were situated in soils varying from wet, black silt to dry sand.

The idea of using electropotential measurements to indicate the extent of corrosion on tower footings fitted into the need of The Detroit Edison Company for making such determinations. This paper is a summary of the information obtained from such an electropotential survey.

## Theory for Using Potential Measurements as a Criterion for Determining Which Towers Need Cathodic Protection Other Than That Afforded by Galvanizing

The theoretical potential E of zinc (or unbroken galvanizing on a tower) against a copper-saturated-

\* A paper presented before the Edison Electric Institute Transmission and Distribution Committee, Denver, Colo., May 25, 1950, and the Seventh Annual Conference, National Association of Corrosion Engineers, New York, N. Y., March 13-16, 1951.



### Abstract

1. The measurement of the tower-to-soil potentials provides a means by which the condition of the galvanizing on underground portions of towers can be predicted with fair accuracy.

2. The electropotential measurement technique has the advantage over the chemical and visual methods of being so rapid that many towers can be checked in the time it takes to examine one by either of the other methods.

3. The potential measurement gives the over-all condition of the underground portion of the towers instead of the condition at the relatively small areas that it is practical to expose for visual observations or chemical test.

4. The tower potentials at switching station ends of The Detroit Edison Company's transmission lines are much lower than those that are considerable distances from the stations. Potentials are also low for those towers situated near steel poles set in concrete and grounded individually.

5. The low potential at the station ends is due in part to the fact that the grounding medium for the stations is massive steel and copper. Similarly the steel poles set in concrete are connected to grounds of either copper rods or pieces of iron.

6. The disconnection of the overhead ground wire from the station structure usually caused the potential of towers adjacent to the station to increase. In some cases the increase in potential has been great enough to indicate that the towers are adequately protected by the galvanizing remaining on them. In other cases the potential remained low after the ground wire was insulated from the station. This indicated some other means of protection was needed.

7. Potential gradients do exist at locations other than at station ends. These gradients are usually downward in the direction of the tower having the greatest loss of galvanizing due to corrosion.

8. The potential measured is not always the true potential of an individual tower because the overhead ground wire permits nearby towers of lower or higher potential to influence the potential of any individual tower.

copper-sulfate solution half cell is, at 18 C, approximately:

$$E = 1.10 + 0.029 \log \frac{C_{Cu^{++}}}{C_{Zn^{++}}}$$

where  $C_{Cu^{++}}$  is the effective concentration of a cupric ions in a saturated solution of copper sulfate and  $C_{Zn^{++}}$  is the effective concentration of zinc ions in contact with galvanized tower legs. The theoretical value for E for a new galvanized tower will depend upon the  $C_{Zn^{++}}$  which is not known. Values obtained for galvanized towers just installed are as high as 1.12 volt.

The theoretical potential E of bright steel against a copper:saturated-copper-sulfate solution reference electrode is:

$$E = 0.785 + 0.029 \log \frac{C_{Cu^{++}}}{C_{Fe^{++}}}$$

where  $C_{Fe^{++}}$  is the effective concentration of ferrous ions in equilibrium with the iron. This theoretical value will vary with  $C_{Fe^{++}}$ . Between the value of E for zinc and E for bright steel is a range of values for the various iron-zinc alloys. Since the  $C_{Fe^{++}}$  is not known, absolute criteria cannot be established to indicate whether the steel is being adequately protected by the galvanizing remaining upon it.

\* The sign of the potentials is minus with respect to the reference electrode.

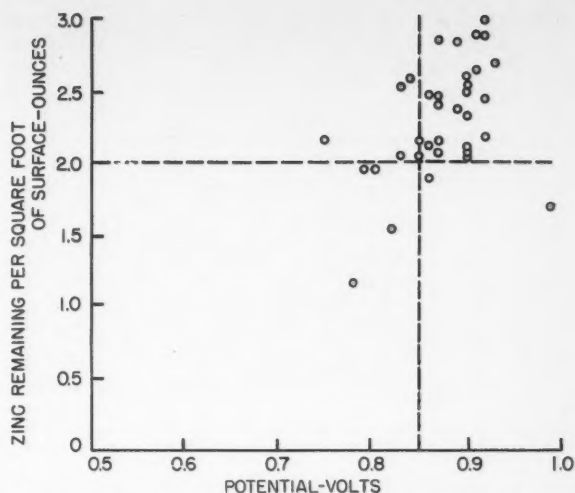


Figure 1—Comparison of potential measurements and weight of zinc by chemical stripping.

It was tentatively assumed that: 1) for those towers that have a potential, with respect to the reference electrode, of less than 0.80 volt, the iron is not being protected; 2) the iron of those towers having potentials of between 0.80 and 0.85 volt is probably receiving some protection from the zinc or zinc-iron alloy layer; and 3) the iron of those towers having a potential of 0.85 or higher is probably being adequately protected. Miller<sup>2</sup> estimated that the potential of rusty steel with respect to a copper sulfate electrode (converted from hydrogen as a reference) is 0.59 volt. Evidently rusty steel can give a still lower potential as shown by the reports of Yelton and Featherly, previously cited.

Uncertainty in the application of the theory led to experiments to determine the validity of the tentative criteria used to indicate the condition of underground portions of transmission towers.

### Preliminary Survey

A preliminary survey was made to determine the potentials of those towers that were studied previously by visual examination and by determination of average thickness of galvanizing on replacement tower members.

The potential measurements for this preliminary survey were made by means of a Leeds and Northrup No. 7663-A1 Universal pH Potentiometer. The tower metals and their ions constitute one half-cell. A copper:saturated-copper-sulfate solution constituted the other half-cell, which was the reference electrode. The reference electrode was inserted into the soil to a depth of about one foot at a point approximately in the center of each tower. Connections were made from the potentiometer to the tower and to the reference electrode by means of alligator clamps.

Data obtained from the preliminary survey made in 1947 are compared with the average results of the earlier visual and chemical observations made in 1936, 1938, and 1943 in two ways. The first made use of a plot of the weight of zinc, in ounces per square

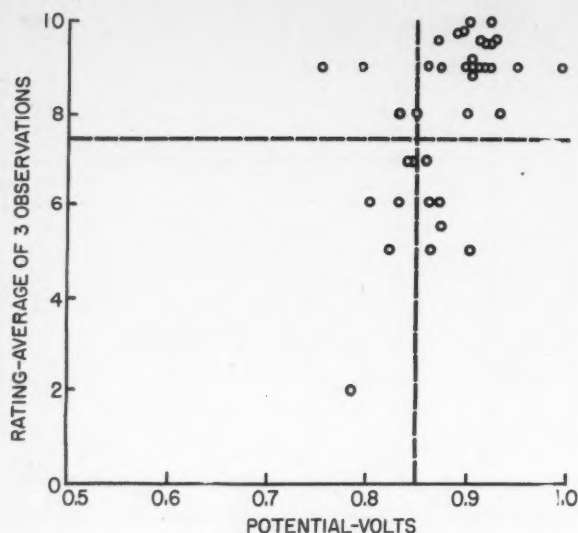


Figure 2—Comparison of potential measurements and visual observations of towers in service.

foot, that remained on the tower member examined versus the potential measured. The plot is shown in Figure 1. The vertical line at the value 0.85 volt indicates the potential which was selected tentatively as the probable minimum to indicate adequate protection. The horizontal line through 2.0 ounces per square foot indicates the weight of zinc coating specified on the tower structure when it was new. This weight is considered to be adequate for protection against corrosion. The plot shows that 25 of the 36 points fall in the area above 2.0 ounces per square foot and to the right of 0.85 volt. Four points fall in the area below 2.0 ounces per square foot and to the left of 0.85 volt. This shows that a correlation of approximately 80 percent existed between the two methods of evaluating the extent of corrosion on the sub-soil portion of the towers.

The second way of summarizing the preliminary survey results is shown in Figure 2. This is a plot of the results of visual observations on the underground parts of towers versus the potential measured for the towers concerned. In order to plot the results of the visual observations, the following numeral ratings were assigned.

Rating	Observation
10	Sound zinc coating
9	White deposit
8	Gray deposit
7	Dark and light spots
6	Brown deposit
5	Black deposit
4	Scattered light rust
3	Red deposit
2	Pitted
1	Large number of rust spots

The visual observations were made by three different observers, two of whom assisted in assigning the ratings given above.

The horizontal line through 7.5 in Figure 2 was

selected arbitrarily as the criterion of minimum satisfactory quality. The vertical line through 0.85 volt has the same significance as in Figure 1. The plot shows that 24 of 39 points are in the area above 7.5 and to the right of 0.85 volt and by both methods were considered to be in good condition. Six of the 39 points fell in the area below 7.5 and to the left of 0.85 volt and were judged to be in poor condition. Nine towers show conflicting results. The correlation then was 77 percent.

The reason for the lack of perfect correlation may be: 1) the area concerned in the chemical test and visual observations was small and the tower member involved extended into the ground only to a depth of three feet; 2) local ground currents or interference potentials may have affected the potential readings of a few of the towers.

The degree of correlation obtained seemed to indicate that the electropotential method could be used to predict with reasonable accuracy the extent of the corrosion on tower footings.

Before undertaking an electropotential survey of the entire system, however, further work was done to verify the accuracy of the method.

#### Further Verification of the Potential Method

As previously stated, three potential ranges had been selected to measure the extent of the corrosion on tower footings. The preliminary investigations showed that a rather good correlation existed between the potential ranges tentatively established and the actual results of chemical tests and visual observations on tower members that extended to a depth of only three feet below the ground level. It was realized that the extent of corrosion of such tower members might not be a true indication of the amount of corrosion of the entire tower leg which extends to depths of 9 to 12 feet below the ground line.

Consequently, four towers: a) one having a potential of less than 0.80 volt, b) one between 0.80 and 0.85 volt, c) one approximately 0.85 volt, and d) one greater than 0.85 volt were selected for further ob-

TABLE I  
Correlation Between Electrochemical Potential Measurements and Visual Observations Made on Entire Tower Legs

Potential Ranges Represented	Measured Potential Ground Wire Connection		Visual Appearance
	On	Off	
Below 0.80 volt	0.721	0.786	Bare patches of steel covering somewhat less than half the area beginning approximately 4½ feet below surface and extending downward. Steel was not rusted. Remainder of the area covered with a thin layer of iron-zinc alloy.
0.80 to 0.85	0.729	0.812	A few square inches of unrusted bare steel occurring in spots between 6 and 8 feet* below surface. Remainder covered with a thin layer of iron-zinc alloy.
0.85	0.855	0.865	Entire leg covered with a thin layer of iron-zinc alloy.
Above 0.85	0.894 0.861	0.956	Entire leg covered with iron-zinc alloy.

\* This was a heavy tower used at a turn in the line. The tower legs extended approximately 12 feet below ground level. The depth of the other tower footings was approximately 9 feet.

servation. Sufficient earth was removed from the vicinity of one leg of each of these four towers to allow observers to examine the condition of the leg over its entire length. The results of these observations are shown in Table I and in Figures 3 and 4.

The table shows that for the four tower legs examined, the visual observations substantiate the tentative interpretations assigned to the ranges selected. Figure 3, for example, shows the condition of a portion of a leg from a tower having a potential of 0.786 volt after being disconnected from the overhead ground wire. Clean bare steel and iron-zinc alloy coated areas are indicated in the picture. The iron-zinc alloy areas are all that remain of the original galvanized coating. A tightly adherent white coating (probably basic zinc carbonate) was found on the surface after the mud had been removed in the cleaning operations.

Figure 4 shows, for contrast, a portion of another leg six feet below the ground level, from a tower having a potential of 0.956 volt after being disconnected from the overhead ground wire. No bare steel was evident. The leg had a sound coating of zinc-iron alloy that remained from the original galvanizing. Some of the tightly held white layer which was described previously appears in the picture.

Later, during the survey of the entire system, a peculiar condition was found at one of the towers. The potential varied irregularly on the same day from 0.546 to 0.702 volt with the ground wire connected and from 0.614 to 0.921 volt with the ground wire disconnected. A large manufacturing plant was located near this tower. Stray ground currents from this plant probably caused the wide variation in potential observed.

During the course of re-routing of a part of the tower line, the tower having the varying potential was abandoned. One of the legs was removed from the ground for visual observations and chemical tests to determine the amount of zinc on the surface. Figure 5 shows a portion of this leg. Numerous lightly etched areas of bare steel indicated by arrows were found at approximately the center of the underground part of the leg. When received at the laboratory these areas were lightly rusted. The appearance of the rust indicated that it probably occurred after the leg was taken from the ground. The area of the rusted surface was approximately 32 square inches. The remainder of the tower leg below the ground line was coated with a zinc-iron alloy layer that varied in zinc content from 1.05 to 1.5 ounces per square foot\* and a tightly adhering white deposit.

The cases that have been described gave the verification needed to substantiate the theory that in the absence of stray ground currents a correlation exists between the potential of a tower with respect to a reference electrode and the actual amount of corrosion that has occurred on the underground part of the tower structure. Consequently, a potential survey of the entire overhead transmission tower system was made during the summers of 1947, 1948, and 1949.

\* The microscopic structure of the galvanized coating was interpreted according to "Metallography of Hot-Dipped Galvanized Coatings," D. H. Rowland. *Trans. ASM*, 40, 983-1011.

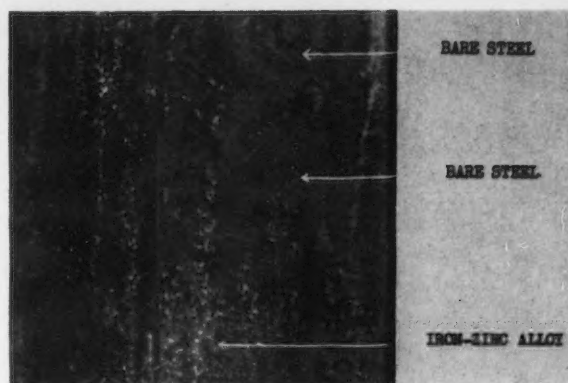


Figure 3—Portion of a tower leg from six feet below ground. Potential was 0.786 volt after disconnection from ground.



Figure 4—Portion of a tower leg from six feet below ground. Potential was 0.956 volt after disconnection from ground wire. Surface was coated with layer of iron-zinc alloy and white basic zinc carbonate.

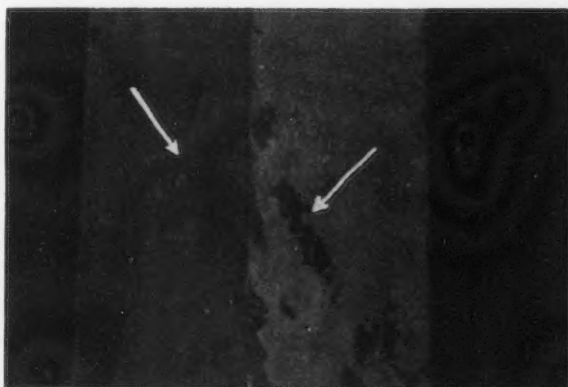


Figure 5—Portion of a tower leg from about midway of the buried portion. Potential varied widely. Arrows indicate bare and lightly rusted steel.



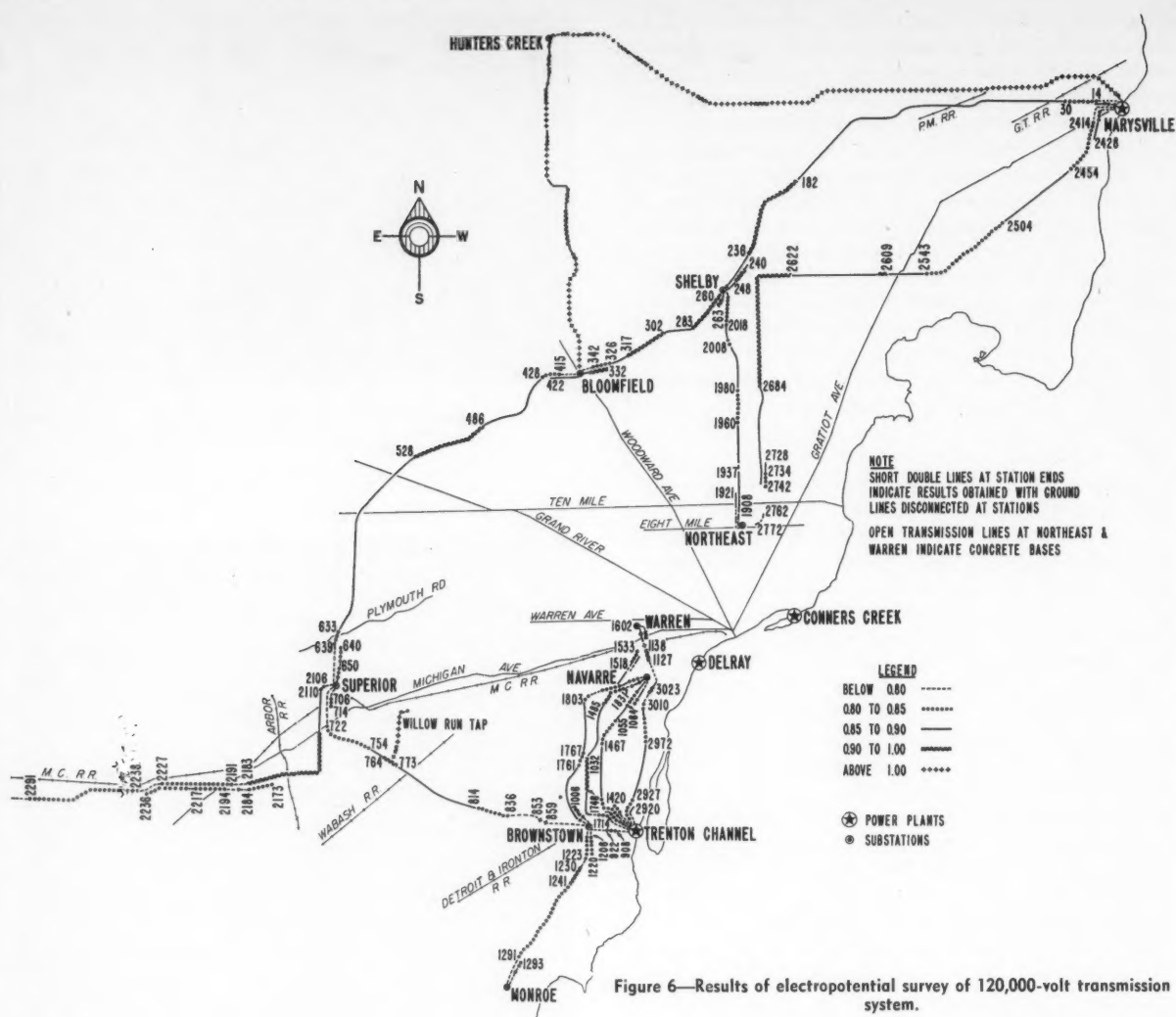


Figure 6—Results of electropotential survey of 120,000-volt transmission system.

### Survey of the System

A survey of all the overhead line transmission towers in The Detroit Edison Company system was made in a manner similar to that used for the preliminary survey described previously. The only changes were 1) to substitute a Coleman pH Electrometer for the Leeds and Northrup Potentiometer and 2) to place the reference electrode adjacent to one leg rather than in the center of the area outlined by the four tower legs.

The results of the electropotential survey of the towers are shown graphically on the map in Figure 6. This graphical presentation shows that the lowest potential existed at the station ends of the lines. Several of the values were less than 0.7 volt.

### Effect of Station Ground Mass

The station ground masses consist of copper rods and massive pieces of iron. Consequently, the potentials of these stations with respect to the reference electrode were lower than those of the towers. In effect, the ground wire produced a short circuited cell in which the towers adjacent to the station were

acting as anodes and the station ground mass as the cathode. With a cell thus shorted it seems probable that any bare steel on those towers would not be protected from corrosion. It was not possible, however, to predict whether areas of bare steel actually were present. In order to do this precisely with potential measurements it would be necessary to disconnect the overhead ground wire from individual towers and allow the towers to come to equilibrium potentials. This procedure actually was followed at numerous towers, data for a few of which are shown in Table I. However, such disconnections are a time-consuming operation.

The effect of the station ground mass was studied by inserting a 10-inch suspension insulator at the station ends of the overhead ground wire. The ground wire was disconnected from the station ground for periods varying from two hours to several months. Then the potentials were remeasured for those towers in the vicinity of the station. The usual procedure was to measure potentials of consecutive towers until towers were reached where virtually the same potential was obtained with the ground

either connected or disconnected. Changes in potential of a few thousandths of a volt were observed as far away as 50 towers from the station at the instant that the ground line was disconnected.

The effect of insulating the ground wire at the station end is illustrated in Figure 7 in three characteristic patterns. The top graph shows a case where the potentials increased from 0.7 volt to about 0.85 volt when the ground wire was insulated from the station. This case shows that if the ground wire is insulated from the station little or no cathodic protection is needed at this time.

The graph in the middle of Figure 7 shows the condition found at a small switching station. Even with the ground wire connected only a few of the towers had potentials lower than 0.85 volt and none were less than 0.8 volt. With the ground wire insulated the potentials were much higher. These towers were probably adequately protected even with the ground wire connected at the station. However, with the ground wire connected the deterioration of the galvanizing on these towers is probably accelerated.

The lower plot in Figure 7 shows a case where the first 16 towers from the station had potentials below 0.80 volt even with the ground insulated. Further, the amount of increase in potential at these towers when the ground wire was insulated was very small. This is clearly a case where cathodic protection is needed. This latter case shows the condition that existed at most of the station ends.

#### Relationship of Soil Type to Potentials

An effort was made to correlate the results of the potential measurements with the type of soil\* in which the tower was located. It was found that the effects of the station ground obscured any effects the various types of soil listed in the survey maps may have caused. Towers in local areas which were inclined to be wet much of the time, however, usually had lower potentials than nearby towers located in dry soil. This condition was noted especially at several towers in the line far enough north of Superior Station to be beyond the effects of the station ground. Soil type does not seem to offer the explanation for the low potential on the Superior-Blackstone line. This line passes over rather open farm land. It is possible, however, that cross-country oil and gas lines which are being cathodically protected might contribute to the irregularities found in this location. Further investigation of this region is planned for the future.

#### Local Fluctuating Potentials

The potentials for the greater part of the towers are constant within about 0.01 volt over a period of several months. However, in several locations on the company system some towers had potentials, with respect to the reference electrode, that fluctuated as much as 0.3 volt. There were two types of such locations, namely: Type I, within city limits where stray currents from manufacturing plants and trolley lines were assumed to be responsible; and Type II, in

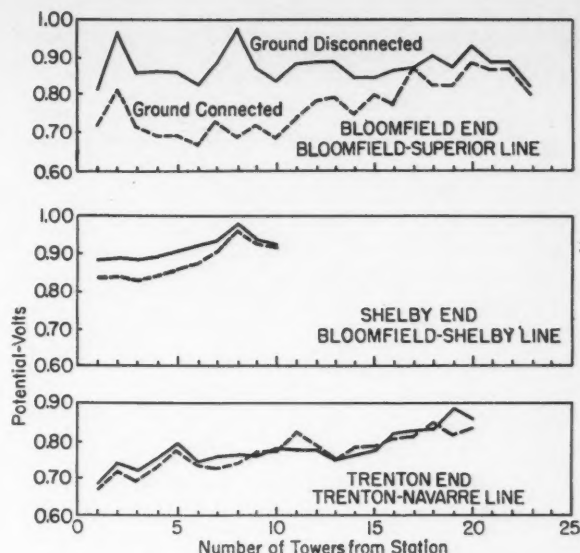


Figure 7—Effect of disconnecting ground.

open country farm land away from any of the interferences of Type I. The vicinity of Navarre Station as shown on the map in Figure 6 is an example of Type I. At this location the potential varied in some cases from 0.5 to 0.8 volt. No definite period or frequency was observed for these variable potentials. These towers have been in the ground approximately 25 years. After that length of service corrosion might be expected, but that does not account for the wide variation in potentials.

The territory about five miles from Hunters Creek Station was the site of an example of Type II. At this site the potentials of a few towers varied rapidly and irregularly with time from 0.75 to 1.0 volt. These towers had been in the ground about one year when the measurements were made. Consequently, little or no corrosion was expected to be found on those towers. The origin of these fluctuating potentials in these isolated regions is not known.

Such conditions of fluctuating potentials have caused concern. It is assumed that these fluctuating potentials indicate the presence of stray currents which are reported to cause localized pit-type corrosion.<sup>3</sup> Some verification for this assumption is shown in Fig. 5. Fluctuating potentials had been measured at this tower and lightly etched areas (probably the beginning of pitted spots) were found on the tower leg.

#### Experiments in Cathodic Protection

As early as 1940 The Detroit Edison Company had considered the use of magnesium for cathodic protection of towers from which the galvanizing had been removed by corrosion and through the cooperation of Dr. John Grebe of Dow Chemical Company magnesium rods were obtained for this purpose. Before they could be put in use experimentally, they were released to the government for use in World War II and all experimental work was deferred until 1946.

\* Data obtained from: 1) Soil Survey Maps, U. S. Dept. of Agriculture.  
2) Geologic Atlas, U. S. Dept. of Interior.

TABLE II  
These Towers Were Selected for the Experimental Installation of  
Magnesium Anodes

Tower No.	Original Potential July, 1947 (Volt)	Potential, Ground Disconnected at Superior Station October, 1948 (Volt)
595.....	0.818	.....
622.....	0.831	0.831
625.....	0.831	0.897
628.....	0.818	0.837
649.....	0.748	0.776
654.....	0.767	0.837
655.....	0.708	0.805
656.....	0.708	0.825
657.....	0.721	0.797
700.....	0.685	0.754
701.....	0.756	0.819
702.....	0.756	0.793
703.....	0.691	0.741
2101.....	0.685	0.773
2102.....	0.721	0.805
2103.....	0.748	0.797
2104.....	0.779	0.812
2105.....	0.812	0.831
2109.....	0.837	0.855

After the electropotential survey previously described had shown some of the towers to be in need of cathodic protection, an experimental site was selected where the survey showed the tower footings had corroded considerably. Nineteen towers, listed in Table II, located in the vicinity of Superior Station were selected for this experimental installation. A number of magnesium anodes of the Galvo-Pak type were installed as recommended by R. L. Featherly, then of Dowell Incorporated. Anodes were installed at these towers in October, 1948, and July, 1949. At the time of the first installations 10-inch suspension insulators were placed in the ground wire so that the towers were insulated from the station ground. The towers in this vicinity are being observed periodically to determine the effects of the protective measures taken.

#### Instrumentation

The Coleman pH Electrometer slightly modified was used as a vacuum tube voltmeter having an internal impedance of approximately  $1 \times 10^{12}$  ohms. In field work it was found occasionally that unpredictable and non-periodic voltages appeared at the terminals of the voltmeter. In order to eliminate or reduce these effects, an "R-C" (resistance-capacitance) type filter was designed to pass no voltage disturb-

ances having a frequency greater than 0.1 cycle per second. At the same time this filter did not measurably diminish the steady dc components. The filter was inserted between the voltmeter and the measuring point.

The reference electrode used for the potential survey was similar to one designed by Dow Chemical Company. It consisted of a 3/16-inch copper rod in a saturated solution of copper sulfate. The copper rod and copper sulfate solution were contained in a bakelite tube with a porous wood plug at the end that made contact with the soil.

#### Conclusions

From the results presented it can be concluded that approximately half the towers that have been in the ground 20 to 30 years are adequately protected against corrosion of their underground structures. This protection is afforded by the remnant of the original galvanizing that is on the structures. However, many of the towers at the station ends of the transmission lines and in the vicinity of concrete based steel poles are either poorly protected or unprotected.

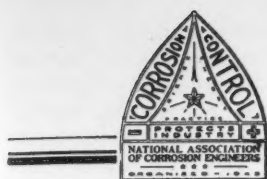
The information obtained to date on the towers at which anodes have been installed indicates that unless the overhead ground wire is insulated from the station structure the magnesium anodes are unable to protect the tower footings. The magnesium anode cannot produce sufficient counter emf to overcome the cumulative effects of the corrosion on the tower structure and the massive station electrical ground.

The preliminary work on the experimental anode installation has been insufficient to make definite conclusions regarding the type of anode most suitable and whether this type of cathodic protection is adequate. Additional data will be gathered and presented at a later date.

#### References

1. Kerstein and Gibson. "Deterioration of Tower Galvanizing Checked Periodically." *Elec. World*, 126, 82 (1946) Oct.
2. M. C. Miller. "Corrosion of Buried Metals and Cathodic Protection." *Petro. Eng.* (1944) Mar.-June incl.
3. J. A. Clay. "Insulation of Pipe Fittings with Plastics." *Oil World*. (1949) April.





# Discussions

**Application of Corrosion Resisting Materials to Railroad Electrical Construction.** H. F. Brown. *Corrosion*, 6, No. 8, 268-273 (1950) Aug.

**Discussion by H. P. Godard, Aluminum Laboratories, Ltd., Kingston, Ont., Canada:**

From the introduction and abstract of the paper "Application of Corrosion Resisting Materials to Railroad Electrical Construction" it is implied that the main purpose of the tests was to determine the corrosion behavior of a large number of materials in the smoky atmospheres along a steam railroad right-of-way. One of these materials was aluminum, in the form of bar specimens, trolley clips and stranded cable. I would point out, however, that the manner in which the aluminum specimens were suspended caused an appreciable amount of galvanic corrosion and contributed materially to their unfavorable performance. The results, therefore, do not fairly represent the behavior of aluminum in the atmosphere described.

In the Cedar Hill roundhouse stack the aluminum round bars were threaded through one end onto a copper rod. The aluminum alloy trolley clips were bolted to copper wire. In both cases galvanic corrosion caused by contact with copper in the aggressive atmosphere undoubtedly accelerated deterioration of the aluminum. This can be seen in Figure 6 of original paper in which specimens 0401-0402-0403 are tapered—showing more corrosion near the point of attachment to the copper rod. The aluminum cable specimens were placed horizontally near the bottom of the support frame. In this position condensation and drip from specimens above them would fall onto the cable. As the bulk of the upper alloys were copper-bearing, this is most unfavorable to aluminum and would lead to "deposition corrosion" due to copper plated out from the falling drops.

In the Hemphill tunnel test the round bar specimens (see Figure 2) and the cable specimens (see Figure 3) were attached snugly to a bronze messenger cable by means of copper tie wire. This practice would also lead to appreciable galvanic corrosion of aluminum in the aggressive tunnel atmosphere.

The Lambert Point round bars were tied with copper wire to an overhead copper trolley wire, which would also tend to corrode the aluminum specimens, although to a lesser extent than in the two other locations owing to the less corrosive atmosphere.

Aluminum would not be expected to perform well under the conditions of test, and it is unfortunate that this otherwise excellent work should have ignored the precautions that would be necessary in making an actual aluminum installation.

If the tests were planned to see whether aluminum could be used in contact with copper alloys the result is conclusively negative as could be predicted, but this distinction has not been clearly made in the published article.

## Author's Reply:

As indicated by the title of the report and as mentioned in the introduction, the primary purpose of the study was to determine the most economic materials to be used in connection with catenary contact systems and other electrical construction suspended above the center line of railroad tracks and relatively close to the stack emission from steam locomotives.

It was recognized before these tests were made that there would be possibly some electrolytic action between dissimilar metals which would be fastened to the copper or bronze supporting rods or wires. However, this test was in its original concept designed to investigate the most economic materials which could be used in contact with copper conductors, since this is the most suitable material for contact systems. It was therefore important to find **those materials which would stand up well in contact with copper or bronze**, as well as the materials which would not do so.

Mr. Godard is quite correct in pointing out that the aluminum samples, particularly the round samples, show very clearly the effect of the drip from the overhead copper or bronze samples. This was; however, not more unfavorable to the aluminum than to some of the other samples or ferrous materials.

In the complete report the unfavorable performance of the aluminum trolley clips, as compared with the clips made of other materials, some of which were ferrous materials, is also clearly shown.

It will be seen from the foregoing that any precautions which might be taken to keep aluminum parts from copper or bronze parts would not have given the results desired in the tests as actually made, because it has been considered impossible to make an all-aluminum contact system, much as it would be desirable because of the extreme lightness of the material itself. Since bronze wire is used almost universally for contact conductor, it was necessary to find the materials which would perform well in contact with it. That is why the samples installed in the Hemphill Tunnel and at Lambert Point were also suspended in contact with the copper supporting wires.

Some smoke box tests made prior to the work done by the AAR, in which some sheet aluminum parts were suspended from a wooden support by aluminum

wires, gave unsatisfactory results as compared with other materials.

This same deterioration has been noted in a more recent test where a stranded conductor consisting of three aluminum strands with four stainless steel wires to make a seven strand cable was placed across the smoke stack with non-metallic supports. After about six months' exposure the aluminum wires were practically destroyed in this test.

It is because of this performance that the statement in the summary was made that, "Aluminum is not a satisfactory material for stranded conductors over a steam railroad."

**The Role of Polarization in Electrochemical Corrosion.** By R. H. Brown, G. C. English and R. D. Williams. *Corrosion*, 6, No. 6, 186-195 (1950) June.

**Discussion by J. V. Petrocelli, The Patent Button Company, Waterbury, Connecticut:**

I believe that the authors' comments concerning my work on polarization curves, their reference No. 7, may be somewhat misleading. They refer to this work and the technique used therein as, "... the weight loss method as used ..." I should like to point out that the concept of a "mixed potential" for the interpretation of polarization curves as introduced in my work is not a weight loss method. It was shown that at least in certain cases, an evaluation of the local and anodic polarization curves as well as of the local action current may be made by means of polarization techniques alone. The weight loss data, and the curves based thereon reported in my work were for the sole purpose of verifying the polarization technique introduced.

On page 193 the authors discuss IR drops across ohmic resistances at the metal-liquid interface. It is generally accepted that for practical ranges of currents an ohmic resistance has a fairly constant value which is independent of the current, thus yielding the well-known linear relationship  $V=IR$ . In Figure 19, however, the authors show that what they call the ohmic resistance is a rapidly varying function of the current. It is suggested that perhaps the measured quantity, although appearing as a resistance to the measuring circuit e.g. as  $\frac{\Delta E}{\Delta I}$  actually is not a linear ohmic resistance but an electro-chemical polarization effect.

The distinction between an actual linear ohmic resistance and a non-linear resistance effect at the metal-solution interface is very important when mechanisms of corrosion are being considered.

#### Author's Reply:

We wish to thank Dr. J. V. Petrocelli for his comments and regret that he feels our references to his paper<sup>1</sup> were misleading.

Our paper was written as an educational lecture wherein there was no opportunity to discuss the various papers to which we referred in the detail that their importance would warrant in a longer exposition. It was our hope that reference to these papers

would prompt the reader to study them. Notwithstanding, it was neither our intent to infer, nor did we state, that the "concept of mixed potentials" was dependent upon weight loss measurements. We believe that the measured potential of a metal in aqueous solution is the result of several potentials and that these several potentials are polarized to a value corresponding to the measured potential. This idea is not new and goes back at least to work of Evans and Hoar on local action corrosion. Petrocelli has coined the term "mixed potential" to identify this condition and his paper is of great value in demonstrating in considerable detail the manner by which polarization adjusts these various potentials to one value corresponding to the measured value. However, it is our belief that the polarization effects are involved in potential measurements in a much wider sense than Petrocelli has indicated in his paper. Even in the case of a reversible electrode, such as the Zn/ZnSO<sub>4</sub> electrode, the measured potential corresponds to the potential (for the zinc-zinc ion reaction) calculated from thermodynamic data only because all other possible reactions are polarized to the zinc-zinc ion potential. Hence, for example, the hydrogen gas-hydrogen ion reaction is polarized to the zinc-zinc ion potential.

However, we cannot agree that the local action polarization curve obtained by extrapolation (for example, see Figure 4 of the Petrocelli paper) is justified without verification by weight loss measurements such as Petrocelli used. Indeed, in the general case, there is no reason *a priori* that the local anodic curve should be linear, or for that matter, that it should approach linearity. The linear extrapolation is justified only because Petrocelli established by weight loss measurements that the local anodic curve approaches closely the shape of a straight line. The general ideas in this discussion are essentially the same as those in a paper<sup>2</sup> presented in 1949 at the Chicago meeting of the Electrochemical Society.

From Petrocelli's discussion we are not certain whether he is disagreeing or agreeing with our remarks on IR drops at metal-liquid interfaces. Measurements indicate that polarization, as usually determined, involves at least two factors. One factor is the resistance to passage of current through the metal-liquid interface that we have termed electrochemical polarization and that produces a back emf (or an effect simulating a capacitance). The other factor is also a resistance to the passage of current at the same location, but it is an ohmic resistance that may be termed ohmic polarization. The second factor is manifested by a voltage drop across the ohmic resistance. In the case of the first factor, there would not be an  $I^2R$  loss, whereas in the case of the second factor an  $I^2R$  loss would result. Electrochemists have accepted the idea of electrochemical polarization, but the concept of ohmic resistance has not been readily accepted, probably because the ohmic resistance  $R$ , at a liquid-metal interface, is often a function of the current  $I$ . Ohm's law may be stated  $V=IR$  and in the case of most metallic conductors at constant temperature a plot of  $V$  versus  $I$  is straight line and  $R$  is

constant. However, under some conditions  $R$  may vary with  $I$ . An every day example of this variance is encountered in an electric light lamp system where increased current heats the metallic conductor with a resulting increase in its ohmic resistance. In the case of passage of current through metal-liquid interfaces, a number of factors, for example, the thickness of the films on the surface of the metal may vary with current. Hence, the ohmic resistance of the film can vary with current and, under these conditions,  $R$  is a function of  $I$ . If the condition of the films would remain constant, the ohmic resistance of the film would be constant and the usual linear relationship between  $V$  and  $I$  would hold if the resist-

ance of the film was the only factor resisting the passage of current.

It would be theoretically possible for the back emf to be constant, and if this condition existed, then the electrochemical polarization would be a straight line. However, the slope of the line would not be the ohmic resistance of the metal-liquid interface but simply the resistance equivalent of the electrochemical polarization.

#### References

1. J. V. Petrocelli. *J. Electrochem. Soc.*, **97**, 10 (1950).
2. R. B. Mears and R. H. Brown, A Unified Mechanism of Passivity and Inhibition.



## Condensation of

# Report of Technical Practices Committee No. 1— Corrosion of Oil and Gas Well Equipment★

on the Field Testing of 32 Alloys  
in the Flow Streams of Seven Condensate Wells

The discovery of corrosion in condensate wells in 1942 and the subsequent development of information showing the very wide extent of the problem and the possible economic loss due to this cause resulted in the organization of a cooperative investigation of the National Gasoline Association of America, the American Petroleum Institute, the U. S. Bureau of Mines at Bartlesville, Oklahoma, and the National Association of Corrosion Engineers. The activity of the NACE started in July, 1944, with the formation of a Condensate-Well Corrosion Committee to which was assigned the field testing of metallic and alloy materials. This committee conducted a field test of 32 metallic materials in seven condensate wells. A

preliminary test of two types of specimens, a washer-type mounted on a rod with the specimens at right angles to each other and a cylinder-type specimen in which the inside diameter of the specimen was on a line with the inside diameter of the flow line, was run. The test container was inserted in the flow line from the well. The data from the preliminary test was analyzed and it was decided to adopt the washer-type specimen, using four specimens of each material.

The final test was completed, with analysis of the data, in February, 1948, and the report prepared and distributed to the cooperating companies. It was later decided to assemble all the information on the test and publish the entire report. The report contains the following:

Historical Account of Organization  
Statistical Analysis of Preliminary Test  
Condensate-Well Corrosion Test Data  
Analysis of Corrosion Test Data  
Laboratory Test Data  
X-Ray Diffraction Study of Corroded Specimens  
Discussions

The 32 metals tested were the following:

1. Carbon Steel API J-55
2. Carbon Steel API H-40
3. Carbon Steel API N-80
4. Croloy 2¼
5. Croloy 5
6. Croloy 9
7. Croloy 12 (Type 410)
8. 3% Nickel
9. 5% Nickel
10. 9% Nickel
11. Type 304 (18-8)
12. Type 347 (18-S, Cb)

13. Type 316 (18-8, Mo)
14. Galvanized Steel
15. Nickel-Plated Steel
16. Copper-Plated Steel
17. Nickel Metal
18. Copper Metal
19. Aluminum 61S-T6
20. Copper Steel
21. Cor-Ten
22. Cr-Mo-Si Steel
23. K-Monel (Aged)
24. Yaloy
25. Ampco Grade 8
26. Antimonial Admiralty Metal
27. Everdur 1010
28. 11-13 Chrome (Cast)
29. Alclad (3S-H14)
30. 0.40 Carbon Cast Steel
31. Red Brass Alloy 24
32. 70-30 Copper Nickel

The test spools were placed in the flow lines from wells in the following fields:

Spool	Field
1	Katy, Texas
2	Seabreeze, Texas
3	Cotton Valley, La.
4	North Pettus, Texas
5	Brushy Creek, Texas
6	Moore's Field, Texas
7	Bateman Lake, La.

After exposure for 90 days, the specimens were removed, cleaned, photographed, and weight loss and pitting measured. Every effort was made to record complete data on each installation so the supplementary data are quite complete.

The main investigation was supplemented by a laboratory investigation conducted by the U. S. Bureau of Mines at Bartlesville, Oklahoma.

As a result of the project, the condensate-well industry is now using alloy materials quite extensively.

★ Published by National Association of Corrosion Engineers, 919 Milam Bldg., Houston 2, Texas. Per copy: To members of NACE, \$8.00. To others not members of NACE, \$10.00.

# Topic of the Month

## Furan Resin Linings

By R. McFARLAND\*

THE FURAN RESIN group is a relative new-comer in the field of linings, and plastic coatings. Originally, this family of resins was utilized in cast form to produce semi-finished and finished pieces of equipment to withstand corrosive fluids and corrosive atmospheres.

Several companies producing corrosion-proof equipment have developed various equipment items made from cast Furan and special Furan resins and from experience gained in this work the obvious extension of the fine qualities of this material led to the application of this group of resins for lining the interior and exterior of metallic equipment in order to achieve corrosion-resistance.

The author has made a number of applications of this relatively new lining by applying the Furan plastics group as linings on cast iron and cast steel valve bodies.

Initially, these materials were difficult to work with, and it was necessary to develop special techniques and to add chemical modifiers to the resin in order to ultimately achieve the proper application of these materials as linings. Below are listed a series of comments covering the application of these resins to cast iron and cast steel equipment:

**1) Temperature Control in Application:** Temperature control is critical and the requirement depends on the type and concentration of accelerator used. Rapid heating results in undue shrinkage and

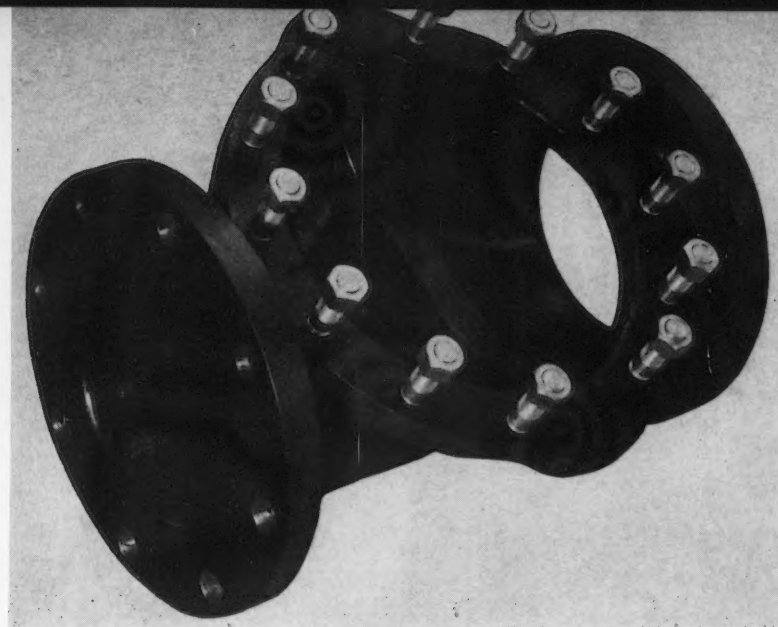


Figure 1—Valve body lined with special furan resin.

cracking of the plastic film in part or entirely through to the base metal. Best results are secured by longer, slower baking with a normal and gradual temperature rise, carefully controlled. Long baking cycles at low temperatures will result in an undercured film.

**2) Curing:** The curing time will depend on the area and mass of the object to be coated or lined, i.e., normal cures will depend on the ratio of the area coated to the total mass, or weight of the metal. Heavy castings may require up to eight hours, whereas smaller and thinner castings or fabricated sheet items may be cured in three hours or less. The accelerator chosen is most

important. Delayed accelerators become active when the baking temperature becomes greater than 150°F. More active accelerators may be used in an emergency for air-dry curing. The resultant cure (air-dried film) does not impart the extreme chemical resistance of a properly, accelerated baked lining or film.

**3) Patching:** Fortunately, this group of resins lends itself readily to cold patching, and thus the films or linings may be easily repaired. The area requiring repairing is roughened. Should the surrounding area be glass-coated, the glaze must be removed with abra-

(Continued on Page 2)

### Resistance

Chemical Service	Time	Temp.	*Performance
HCL (36%).....	18 mo.	R	A
HCL (9%).....	18 mo.	R	A
HF (20%).....	8 mo.	R	A
HNO <sub>3</sub> (30%).....	31 days	R	D
HNO <sub>3</sub> (20%).....	3 mo.	R	C
HNO <sub>3</sub> (10%).....	3 mo.	R	B
(H <sub>2</sub> SO <sub>4</sub> ) (50%).....	12 mo.	R	A
H <sub>3</sub> PO <sub>4</sub> (100%).....	18 mo.	R	A
Acetic (glac.).....	18 mo.	R	A
Chromic (30%).....	2 mo.	R	D
Chlorine, 1500 PPM Solution.....	6 mo.	R	A
NaOH (20%).....	3 mo.	160° F.	A
NaOH (30%).....	12 mo.	R	A
KOH (25%).....	12 mo.	R	A
Sod. Hypochlorite (6%).....	31 days	R	D
Mineral Oil.....	12 mo.	R	A
Vegetable Oil.....	12 mo.	R	A
HCL (9%).....	50/50	12 mo.	R
(20%) C <sub>2</sub> H <sub>5</sub> OH.....	50/50	12 mo.	R
H <sub>3</sub> PO <sub>4</sub> (100%).....	50/50	12 mo.	R
C <sub>2</sub> H <sub>5</sub> OH.....	50/50	12 mo.	R
HCL, Isopropalc. } Vapors.....	6 mo.	235° F.	A
Isoprop. ether.....	6 mo.	235° F.	A
Straight Chain Hydrocarbons.....	12 mo.	R	A
Benzol.....	12 mo.	R	B
Toluol.....	12 mo.	R	A
Zylol.....	12 mo.	R	A
Ketones.....	12 mo.	R	A
Carbon Tet.....	12 mo.	R	A
<b>Esters:</b>			
Et. Acet.....	12 mo.	R	A
Bu. Acet.....	12 mo.	R	A
Glycerine.....	12 mo.	R	A
Ammonia.....	12 mo.	R	A
Ammonium Nit.—Amm. Fertilizer Sol.....	12 mo.	R	A
Gasoline (Sour).....	12 mo.	R	A
Metallic Salts and Hydrochloric Acid.....	18 mo.	R	A

\* Performance Code: A—Satisfactory (no attack).  
B—Slight attack.  
C—Attacked—questionable life.  
D—Unsatisfactory (Failed).

\*Technical Director, Hills-McCanna Company, Chicago, Ill.

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## Topic of the Month

(Continued from Page 1)

sives or etching. The bare steel must be properly primed to prevent loss of accelerator through action on the base steel. The accelerated resin may then be applied and air-dried with ambient temperature curing.

**4) Lining Thickness:** Unsupported film should not exceed 1/16-inch in thickness due to curing difficulties and the possibility of delamination developing in use. Normal lining thickness is 0.20 inch. Heavy films, properly supported by glass cloth, may be installed, layer upon layer, to produce a homogeneous mass up to 1/2 inch thick. Such sections are exceptionally strong and are shock- and shatter-resistant. Excellent adhesion of the resin can be secured to steel or cast iron, but the surface preparation and roughness is most important, as is the type of primer used. Adhesion may vary between 35 psi to 500 psi. Normally, an adhesion of 250 psi is considered entirely satisfactory. These films, when properly applied, bonded and cured, are resistant to thermal shock and have presented no problem in applications of this type.

**5) Toughness:** The toughness and shock-resistance of the material is excellent. For example, the flanges on fittings, pipe and tanks may be given excellent protection against attack or damage from chipping by utilizing a glass cloth in the film before curing. The impact resistance of relatively thin films is adequate for most normal uses.

**6) Surface Preparation:** While the work has been centered about the application of these resins to cast iron and steel, the resin also can be applied to concrete or wood. Wood requires no preparation, but it should be smooth and contain the minimum amount of moisture. Concrete requires careful neutralization and a selected primer. Metal surfaces should be thoroughly and properly sand-blasted and primed with a suitable baking material; or, where the service is not severe, two coats of a special, air-drying primer can be used. In every instance, it is imperative that no oil, dirt, dust or old coating remain on the surface, as none of these materials can be tolerated.

**7) Field Work:** This can be accomplished on equipment if slightly rough films are not objectionable. The working time of the field-accelerated resins is short, and the material cannot be sprayed. As a result, lap and brush marks are present, but these can be removed by sanding and buffing to the finish desired. Sufficient buffing will achieve a very high gloss and smoothness. However, normally, this extreme is not necessary or economically feasible.

**8) Chemical Resistance:** Listed below is a chemical resistance table, listing typical services, and the performance of the properly cured resin film in the services, with resin lining approximately 1/64-inch thick. However, the lining thickness varies in accordance with the severeness of the chemical service.

The resins, as valve linings have been most useful and most satisfactory in containing a number of very difficult-to-handle corrosives. The application of these resins have been made with the Stalpic "E" resin series of the Stalpic Coatings Corporation of Chicago.

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## Chemical Inhibition and Magnesium Use Are Discussed by Philadelphia Section

Topics on the technical program Philadelphia Section meeting February 9 were: "Chemical Inhibition of Corrosion," by G. E. Best of Mutual Chemical Co. and an audio slide film "Combating Corrosion with the Metal from the Sea," by G. E. Mullin, Dowell Inc. district chemist.

The business meeting following the dinner was presided over by H. F. McConomy, chairman. W. H. Aretz, 1951 Conference hospitality committee chairman stressed the advantages of pre-registration and of the conference program for members and their wives.

Membership of North East Region has increased from 590 to approximately 800 during 1950, it was reported to the region board of trustees Tuesday February 6 at the Atlantic Building, Philadelphia. Present were H. L. Hamilton, T. P. May, H. F. McConomy, George Best, W. F. Fair, G. L. Cox and E. R. English. It was decided, after a discussion on membership, it is necessary for sections to continue membership activities.

New Haven, Conn. and Boston, Mass. are considered prospective locations for new sections, trustees agreed. Mr. Fair will canvass members in those areas to see if they are willing to take the initiative in organizing sections.

### Conference Is Discussed

Mr. Hamilton called attention to the coming New York Conference and expressed the hope a high percentage of members in the region would attend. He said, however, many new members have received no mailings from Houston concerning the conference and said it appears the cause is the lapse of time between receipt of a member's application and dues and the time his name is placed on the mailing list.

NACE cooperation in educational programs of various kinds was discussed.

Dr. T. P. May was named coordinator of section activities, and section representatives were asked to continue established procedure in sending announcements of section meetings to officers of the national organization, directors, and officers of every region and section in the country. Other responsibilities were

assigned as follows: W. F. Fair, membership; H. F. McConomy, section functions; George Best, rules and regulations.

### Section Officers' Guide Proposed

Mr. McConomy suggested the region publish a guide for section officers listing requirements for reports, magazine deadlines, financial reports and other information. He was asked by Chairman Hamilton to prepare a tentative list to be sent for comment to section chairmen and published by the region secretary.

A tentative schedule of meeting dates for region organizations was given as shown below.

It was agreed joint region-section meetings should be held in the spring and fall. The secretary was instructed to write to V. V. Kendall, Pittsburgh Section chairman concerning holding a spring meeting May 3 at Pittsburgh. The fall meeting is scheduled tentatively for Philadelphia, but this will be changed if a section is organized in New England.

Status of rules and regulations for sections was reported as follows: Philadelphia, approved early 1950; Metropolitan New York Section, approved Nov. 27, 1950; Baltimore Section, submitted for approval, to be checked by Mr. Best; Western New York Section, in process of formation; Pittsburgh Section, status unknown.

### May Named to Committee

T. P. May was named to represent North East Region on the national association nominating committee which will meet during the March conference. At the same time a nominating committee for regional officers was named as follows for 1952: L. B. Donovan, chairman; T. P. May and J. C. Searer.

Mr. Hamilton was authorized to write to the chairman of the Policy and Planning Committee expressing the opinion of the region trustees a provision should be made for disbursements to sections through regions on a per capita basis with some provisions for a minimum to provide for small or newly-formed sections.

## Baltimore Hears Talk About Vapor Phase Inhibitors in Shipping

"Vapor Phase Corrosion Inhibitors Related to Packaging and Preservation of Materials During Shipping," was the subject of a talk February 8 by H. R. Baker of the Naval Research Laboratory, Washington, D. C. before 20 members and five guests at Baltimore Section's dinner meeting at Park Plaza Hotel, Baltimore. Mr. Baker's talk was a replacement for one scheduled to be given by Dr. Allen L. Alexander who was unable to be present.

Rules and regulations of the section have been presented and approved. Dr. Paul Backman was named program committee chairman. Tentative dates for dinner meetings have been set as follows: March 1, October 2 and December 12.

Following is a summary of Mr. Baker's remarks:

After tracing the origin of vapor phase inhibitors and his own part in their development, the speaker pointed to the need for protecting materials shipped overseas during World War II as a stimulant to development of the materials. The requirements involved not only protecting metals but the necessity of reducing time required to assemble and prepare for use ordnance and other implements. Vapor phase inhibitors reduce preparation time to minutes, a factor which has proved valuable in the Korean war.

The principal inhibitors in this category are organic nitrites whose characteristic volatilization to form protective adsorbed film on metal surfaces has been made known only recently. The nitrite group faces away from the metal and toward the atmosphere while the organic group adheres to the metal. The film, with sufficient inhibitor present, is impervious to water vapor.

Samples of the inhibitors were passed around for examination, the technique of impregnating paper and suspending the paper in a package for protection was illustrated. Materials which can be protected safely by the inhibitors were listed and those vulnerable to attack enumerated. Application of vapor phase inhibitors to a system containing water also was described and the need for a tight package to minimize inhibitor loss was stressed.

Alkaline media favor stabilization of these organic vapor phase inhibitors and acid converts them into nitroso amines, the speaker said. These latter materials are not inhibitors. Organic amines are effective at low temperatures and up to 150 degrees F. Toxicity of the substances is comparable to sodium nitrite.

Tentative Schedule of North East Region Meetings

	Phila.	Met. N.Y.	Balt.	Pitts.	W.N.Y.	Joint R-S	Trustee
March.....	*	Conf. 25		1 5			
April.....							
May.....	16		1	3 7	16	3	3
June.....							
September.....		26			18		18
October.....	10		2			10	
November.....		7 12			19		
December.....	12		4				4

## Films on Painting Seen at New York

Two technicolor films entitled "Exterior Top-Side Painting. I.—Surface Preparation. II — Application," were shown to members of Metropolitan New York Section March 2 at Building Trades Employers' Association, New York City. Frank M. Van Ettin of the Bureau of Ships, Navy Department, Washington, D.C. elaborated on the subject matter of the films. This was the first public showing of the pictures taken of the methods used by the navy in combatting corrosion.

## Nominations for Young Engineers' Awards Asked

Nominations are being received by Wm. H. Trotter, Chemical Engineers of Greater New York, 218 Jerusalem Ave., Massapeque, L. I. for an award to be given an outstanding young chemical engineer in the New York area. The purpose is to give non-monetary recognition to a young engineer for exceptional service to humanity or for outstanding professional achievements. The recipient must be 32 years of age or less. Forms on which nominations may be submitted before April 30 can be obtained from Sidney D. Kirkpatrick, McGraw-Hill Publishing Co., 330 West 42nd St., New York, N. Y.



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## NACE CALENDAR

### Apr.

- 5 Houston Section. Graduating students of University of Houston, Rice Institute, Texas A. & M. and University of Texas interested in corrosion to be invited to attend. R. B. Mears, of United States Steel Co., will speak on "The Role of the Corrosion Engineer in Industry."
- 5 Pittsburgh Section. Program on inhibitors.
- 9 Permian Basin Section.
- 12 Shreveport Section.
- 17 Chicago Section. "The Corrosion Effects of Street De-Icing Salt."
- 17 Cleveland Section. Dinner meeting.
- 18 Los Angeles Section. Rodger Young Auditorium.
- 19 St. Louis Section. "Industrial Application of Aluminum," by Kent R. Van Horn, associate director of research, Aluminum Co. of America. Joint meeting with AIChE and Engineers' Club.
- 24 Cincinnati Section. Panel Discussion: "Distilleries' Process and Corrosion Problems."
- 25 Corpus Christi Section.
- 28 Sabine-Neches Section. Lake Charles area field trip.

### May

- 3 Pittsburgh Section. Theory of Oxidation. E. A. Guldransen, Westinghouse Research Laboratories.
- 8 Houston Section. Effects of Alloying Elements on the Corrodibility of iron, F. L. LaQue, International Nickel Co., Inc.
- 14 Permian Basin Section.
- 15 Cleveland Section. Dinner meeting.
- 15 Chicago Section. Round table discussion.
- 21 Greater St. Louis Section. Effect of Water Treatment on Corrosion in Heat Exchanger Equipment, Leo F. Collins, Detroit Edison Co.
- 22 Cincinnati Section. Panel discussion on pipe corrosion.
- 23 Corpus Christi Section.
- 31 Sabine-Neches Section.

## Spectrographers to Meet At Chicago May 4

American Society of Spectrographers will hold a 14-paper symposium on "Use of Spectroscopy in the Steel Industry" Friday, May 4, 1951, between 9 a.m. and 9 p.m. at Society of Western Engineers Bldg., 84 East Randolph St., Chicago, Ill., large auditorium. Symposium dinner will be at 6 p.m.

Reservations may be made with Ralph H. Steinberg, 9531 Avalon Ave., Chicago 28, Ill.

## Fulbright Awards

Applications must be mailed not later than April 15, 1951, for nominations for Fulbright Awards for 1952-53 in Australia, New Zealand, India, Pakistan, Philippines, Burma, Thailand. They should be addressed to Executive Secretary, Committee on International Exchange of Persons, Conference Board of Associated Research Councils, 2101 Constitution Ave., Washington, D. C.

## Tulsa Section's School for Pipeliners February 21-23 Is Well Attended



### Larrabee Heard on Corrosion of Steel



Seated at the speaker's table are, in the usual order, C. P. Larrabee, F. L. Whitney, W. A. Baumstark and H. O. Nordquist at the February 19 meeting of Greater St. Louis Section.

C. P. Larrabee, in charge of corrosion work for United States Steel Company addressed St. Louis Section's February 19 meeting on "Corrosion of Steels and Related to Environment and Composition."

Principally covered were the structural and low alloy grades, copper alloyed steels and their corrosion resistance under varying conditions of atmosphere, water and soil.

Numerous questions were asked the speaker at the conclusion of his address. Mr. Larrabee has been on the research staff of United States Steel or its affiliates since 1929.

### St. Louis Section Sets April, May Meetings

Meetings scheduled by Greater St. Louis Section include:

April 19—Kent R. Van Horn, associate director of research, Aluminum Company of America, "Industrial Application of Aluminum." This will be a joint AICHE and Engineers' Club meeting.

May 21—Leo F. Collins, chemical engineer, Detroit Edison Co., "Effect of Water Treatment on Corrosion in Heat Exchanger Equipment."

All meetings are scheduled at Garavelli's Adolphus Room.

### Houston Elects

Officers have been elected as follows by Houston Section: Perry Spafford, Stanolind Oil and Gas Co., chairman; Charles Gribble, Metal Goods Corp., vice-chairman; L. G. Sharpe, Humble Pipe Line Co., secretary-treasurer and Charles Scammon, Houston Oilfield Materials Co., delegates to Houston Engineers' Council.

### Joint AICHE-Houston Section Meeting Attended by 113, Including 50 Guests

A joint dinner meeting attended by 113 members and guests of the Southeast Texas Chapter of the American Institute of Chemical Engineers and the Houston Section, National Association of Corrosion Engineers was held February 16 at Bill Williams' Restaurant, Houston. Over 50 members and guests of the organization attended a tour of the Federated Metals Division plant on Market Street Road, Houston during the afternoon prior to the meeting.

F. L. Whitney, NACE North Central Region director, of Monsanto Chemical Co., St. Louis, Mo., discussed the topic "Corrosion—An Engineering Problem." Mr. Whitney began his discussion by reviewing the electrochemical theory of corrosion, and then highlighted problems in design, construction and fabrication of metallic units, with emphasis on dissimilar metal contact and insulation of joints of dissimilar metals.

He also covered metallurgical factors and stress corrosion.

Emphasis was placed on non-technical aspects of the corrosion engineer's

problem, including the job of selling management, accumulation of cost records, and coordinating efforts of research, design, construction and operation personnel to control corrosion. Mr. Whitney showed slides of various types of corrosion failure experienced in his plant.

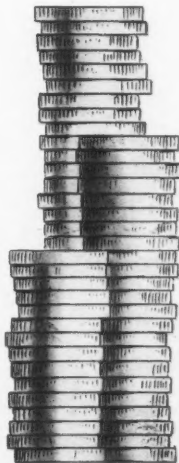
The section approved unanimously the sending of a telegram to L. C. Tuttle, secretary of the section retiring to re-enter the armed forces, thanking him for his work for the section.

### Regional Trustee Named

S. W. McIlrath, Corrosion Engineer, Diamond Alkali Co., Painesville, Ohio, has been elected trustee of North Central Region.

Corrosion mitigation processes and materials are publicized free of charge in CORROSION's "New Products" section. NACE accepts no responsibility for accuracy of performance claims.

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## Shreveport Hears Talks On Rectifier Ground Beds

R. L. Westlake of National Carbon Company was scheduled to address members of Shreveport Section March 8 at Caddo Hotel, Shreveport on "Rectifier Ground Beds." Mr. Westlake's talk included discussions of methods of obtaining greater efficiency, lower ground bed resistance and proper back-fill design. A general discussion was the next item on the program.

## New Orleans - Baton Rouge Officers Named

New Orleans-Baton Rouge Section has elected officers as follows: Henry W. Allen, chairman, Cathodic Protection Service, New Orleans; A. F. Blumer, vice chairman; Philip P. Wogan, Westwego, La., secretary and Darrel F. Griffith, Tretolite Company, Houma, La., treasurer.

## Coating Is Described To Permian Section

Twenty-six members and guests of Permian Section heard William A. Hopwood of Tnemec Company, Odessa, Texas, explain the origins and uses of the coating developed by his company. The material, Mr. Hopson said, was prepared in emulation of the types of coatings nature provides under similar conditions. Materials made by his firm, he said, have been used to coat 40,000 tanks in 30 years.

Next meeting of the section is scheduled March 12.

## Corpus Christi Attends Banquet for Engineers

Members of Corpus Christi Section decided to omit the regularly scheduled meeting for February and instead urge members to attend a banquet sponsored by the Nueces Chapter, Texas Society of Professional Engineers, held February 20 at Corpus Christi. Principal speaker was W. R. Woolrich, dean of the University of Texas engineering school on the subject "Education of Engineers for National Defense."

## Sabine-Neches Meetings

Four meetings have been scheduled by Sabine-Nueces Section as follows:

February 22—Copper Alloy Condenser Tubes, by N. W. Mitchell, Chase Copper & Brass Co.

March 29—Question and answer session by panel.

April 28—Lake Charles area field trip.

May 31—Unannounced.

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## Isthmian Corrosion and Protection Meeting Attended by Several Association Members

A number of members of NACE and the Sea Horse Institute from the United States attended a series of conferences and visits to testing sites during the Isthmian Corrosion and Protection Meeting February 19-24 in the Panama Canal Zone. G. W. Seagren, Stoner-Mudge Fellowship, Mellon Institute reported all visitors from the United States favorably impressed with the volume and quality of corrosion mitigation work underway in the Canal Zone.

The tentative agenda for the meeting included: Summary of results of Panama Canal corrosion and protective coatings studies (H. W. Mundt); summary of projects in progress by Tropical Exposure Station, Naval Research Laboratory (King Williams); summary of projects in progress by Smithsonian Institution, Barro Colorado Island (Dr. James Zetek);

A discussion of underwater corrosion, selection of metals and protective coatings, cathodic protection, overhaul, marine growths, and other details by J. A. Miles; demonstration of laboratory procedures for handling corrosion and protective coating studies (H. W. Mundt); demonstration of application of use of punch cards for assimilation and classification of test data (H. W. Mundt);

Exhibits and tours: Engineering Division, Testing Laboratory, special projects, corrosion and protective coating tests; locks division cathodic protection; tour of Miraflores and/or Pedro Miguel Locks, Gatun Locks; roofing, plastic screens for Gorgas Memorial Laboratory and others.

Among those present were W. F. Clapp, William F. Clapp Laboratories; H. Paterson and P. F. Sheridan, The International Nickel Co., Inc.; C. W. Jackson, Devoe & Reynolds Co., Inc.; H. H. Humble, Dow Chemical Co.; A. L. Alexander, U. S. Naval Research Laboratory; G. W. Van Heuckeroth and R. W. Hill, U. S. Army Engineers; F. M. Van Etten, U. S. Navy, Bureau of Ships; A. O. Allen, Vita Var Corp.; W. J. Mayer, A. M. Byers Co.; E. O. Rhodes, Koppers Co.; B. F. Ames, Maas & Waldstein Co., and Mr. Seagren.

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**Corrosion Problems Related to Air Transport Aircraft**, by Otto E. Kirchner and Fred M. Morris, American Airlines. A paper prepared for presentation at NACE meeting, St. Louis, Mo., April, 1950.

**The Influence of Stress on Corrosion**, by Julius J. Harwood, Office of Naval Research, Washington, D. C. Reprinted from CORROSION, Vol. 6, No. 8 and 9 (1950). A paper presented at the NACE meeting, St. Louis, Mo., April, 1950.

Address your request to: Norman E. Hamner, Managing Editor, Corrosion, 919 Milam Bldg., Houston 2, Texas.

## Electrochemical Meet To Include 120 Papers

Among the 120 technical papers to be presented April 8-12, 1951, at Wardman Park Hotel, Washington, D. C., during the 99th Meeting of The Electrochemical Society will be five reports covering latest research on molybdenum, and others on tungsten, vanadium, germanium, lithium and hafnium.

The Electrothermic Division will offer 25 papers covering high temperature processes, materials and measurements.

## Symposium Scheduled on Carbonate Reservoirs

A symposium on carbonate reservoirs will be a feature of the Second Conference on Increased Recovery of Oil to be held April 19 and 20 at the New Memorial Student Center, Texas A. & M. College, College Station, Texas. The conference is conducted by the Texas Petroleum Research Committee. Paul D. Torrey, Houston is general chairman and Assistant Director Walter D. Rose of the TPRC is program chairman. Prof. Robert L. Whiting, department of petroleum engineering, Texas A. & M. College, is in charge of arrangements and reservations for accommodations should be made through him.

All interested are invited to the conference.

Advance notices of meetings of corrosion interest should be sent to CORROSION in sufficient time to permit publication in an issue distributed before the meetings are held.



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## Instruments Discussion Heard at Los Angeles

A joint meeting of Western Region and Los Angeles Section February 21 heard G. F. Rucker of Leeds & Northrup Company, discuss "Instruments for Cathodic Protection Measurements and their Use." There were present 62 members and guests.

Two ladies among those present were a chemist for a leading protective coatings manufacturer and the other a reporter for Los Angeles and suburban newspapers. The Section business meeting was held first and adjourned, then the region meeting opened.

Three applications for membership were distributed. Next scheduled meeting of Los Angeles Section is April 18.

## Western Region Meetings

The schedule of meetings for units of Western Region includes a joint Region-Los Angeles Section meeting September 19, which may include a field trip and the following meeting dates for Los Angeles Section, all at Rodger Young Auditorium: April 18, June 20 and Nov. 28.

## TP-11 New Chairman

C. E. Imhoff, research supervisor of Allis-Chalmers Manufacturing Co. chemical laboratories, Milwaukee 1, Wis. has been named chairman of Technical Practices Committee 11—Identification of Corrosion Products. There are ten members on the committee.

News about the activities of organizations anywhere in the world engaged in corrosion mitigation are welcomed for use in the news section of CORROSION.

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## Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

### NEW QUESTIONS

**No. 77**—The chemical resistant properties of Teflon, polyethylene, etc., have been well publicized, as has the method of flame spraying these materials on metal surfaces. However, do these plastics retain the same characteristics after being flame sprayed? Also, can they be sprayed pin-hole free?

**No. 78**—In the case of insulated joints in long, uncoated, buried lines which possess tremendous surface areas, such as deep wells and gathering lines, what experimental data exist to prove or disprove that increasing the length of an insulated sections will effectively increase the ability of the insulated joint to stop flow line currents?

**No. 79**—I would like some suggestions as to the types of meters used in making surface potential readings.

**No. 80**—Are cathodic protection currents on welded pipe lines likely to cause arcing if the continuity of the

line is broken for repairs when the current source is

A. A rectifier

B. Distributed anodes.

In either case, would the installation of a temporary bond be advisable before parting the line?

**No. 81**—In the chemical industry what use has been made of cathodic protection, particularly by impressed current, in solving corrosion problems in processing equipment?

**No. 82**—What factors should be evaluated in order to set some sort of a standard method for measuring the corrosiveness of oil well effluents?

## Clippings on Corrosion

Extracted from Current Periodicals

### MORPHINE LEAKS FROM CORRODED CONTAINERS

(From Little Rock, Ark., Democrat, Jan. 25, 1951.)

Wellington, N. Z.—Corrosion in tin foil morphine tubes caused holes through which the contents were lost, New Zealand National Airways Corp. discovered on examining first aid kits in its planes.

### CHANGE SAVES \$118,000 IN COST OF PIER

(From New York Times, Feb. 9, 1951.)

A design change which substituted a method of supporting piers which eliminated the necessity for corrosion resistant bearer points resulted in saving \$118,000 in the cost of Pier 57, North River, the board of estimates said.

### ARMY BUYS TITANIUM

(From N. Y. Journal of Commerce, Feb. 9, 1951.)

Army Ordnance Department has purchased 75,000 pounds of titanium. Certain infantry equipment already is being made from it and it is being considered as material for ship superstructures.

### FOGGER DEVELOPED TO MODIFY NATURAL GAS

(From Guthrie, Okla., Leader, Jan. 30, 1951.)

Blaw-Knox Company, Pittsburgh, has developed a device to inject a stable oil fog into natural gas lines to modify the gas so destruction of lines originally constructed for transportation of manufactured gas will not result. The natural gas, because it is dry and corrosive, dries out leather diaphragms and jute packings, increases internal corrosion and causes difficulty with dust deposits. The oil fog tends to reduce these tendencies.

### Computation Laboratories

The functions of the National Bureau of Standards Computation Laboratory have been enhanced by the completion of NBS Eastern Automatic Computer and the acquisition of several new types of punched-card computers. This up-to-date equipment improves its ability to carry out computations requested by federal agencies, universities and private industry. In addition the laboratory works continuously on the accumulation of tables which can be used to facilitate computations.

### Griebing Is Named

Robert T. Griebing, a fellow of Mellon Institute, Pittsburgh has been named executive secretary of the Air Pollution and Smoke Prevention Association of America, Inc. Headquarters of the association will be moved from Chicago to Mellon Institute at Pittsburgh. The institute has pioneered in research on smoke control since 1911.

### Dr. Blum Honored

Dr. William Blum, chief of the National Bureau of Standards Electrodeposition Section recently was honored by the Electrodepositors' Technical Society of London with election as an honorary member. He is one of six so elected in 26 years of the society's existence.

### About 750 See Motion Pictures at New York

An estimated 750 persons attended the showing of motion pictures during the Seventh Annual Conference and Exhibition of NACE at New York City. Pictures shown were Birth of an Oil Field, Shell Pipe Line Corp.; Building for the Nation, U. S. Steel Co.; Insul-Mastic in Industry, Nicholson and Galloway; Flotation Painting of Water Sealed Gas Holders, Consolidated Edison Co. of New York, Inc., and Somastic Application, Bechtel Corp. and H. C. Price Co.

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## Closer Agreement Among Accelerated Coating Tests Is NBS Laboratory Objective\*

A SPECIAL LABORATORY, recently designed and constructed by the Building Technology Division of the National Bureau of Standards, eliminates the major difficulties that have in the past led to anomalous results in the accelerated durability testing of exterior covering materials. Developed primarily for studying organic coating materials such as asphalts, tars, and paints, the new facilities are sufficiently flexible to meet the requirements of most materials exposed to weathering.

Materials intended for outdoor use are frequently exposed in the laboratory to regular cycles of artificial sun light, heat and water for the purpose of hastening their deterioration. Although such exposure—called accelerated weathering—is generally accepted as a means for determining the relative resistance of similar materials to weathering, results obtained by different laboratories, and even by the same laboratory, do not always show good agreement. This lack of correlation results from variables inherent in the testing procedures that have in the past been largely uncontrolled. These include solids content of the water supply, fluctuations in the light intensity, and irregular operation of the system due to failure of one or more functions while the others continue to operate.

Automatic control of all functions, and of the temperature and purity of the water within narrow limits, assures uniform operation at all times of the bureau's improved accelerated weathering laboratory. The room, 16 by 25 feet in size, is maintained within  $\pm 1^\circ\text{C}$  of any desired working temperature, at present,  $27^\circ\text{C}$ . The relative humidity is not controlled directly, but remains in the range of 40 percent to 60 percent as a result of the subcooling of fresh air brought into the room. The floor area is divided into three portions: a central

working space and two areas enclosed in hoods to house the testing machines.

In one hood are six machines built at the bureau to utilize the enclosed carbon arc as a source of light. The operating range of each light is regulated at 130 to 145 volts and 15 to 17 amperes by means of chromel C ballast resistors in series with the arc. An aluminum drum 31 inches in diameter and holding sixty exposure panels ( $2\frac{3}{4}$  by 6 inches) is rotated around each arc at a rate of one revolution per minute. Air at ambient conditions is circulated around the panels at a low velocity until they reach a predetermined maximum temperature. At this time a thermo-sensitive element mounted in one of the panels turns on the high speed blower, which materially increases the air flow and thereby reduces the panel temperatures. Deionized water, controlled by a cycle clock, can be sprayed on the test panels for any portion of their exposure period.

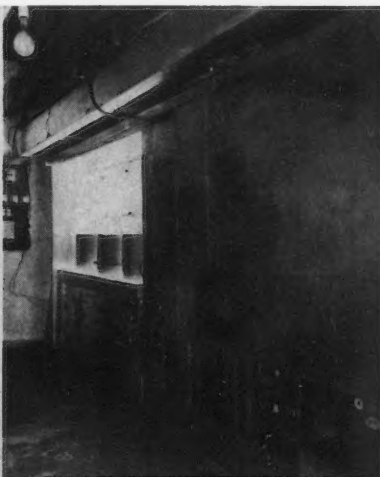
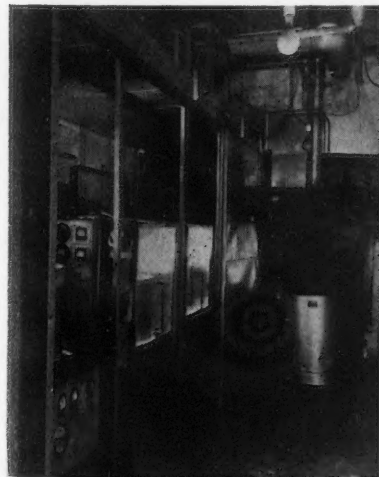
### Time Relay Control Tests

The heart of each machine is a time-delay relay which turns off all functions of that machine if the arc should cease to operate for a period in excess of 30 seconds. Voltage and current are continuously indicated while the running time and power consumed by the arc

(Continued on Page 10)

Figure 1—Overall view of the NBS new laboratory for accelerated durability testing of exterior coating materials. In the hood at right are six weathering machines built at the bureau and based on the enclosed carbon arc as a source of light. The hood on the left encloses four modified commercial Weatherometers. The water-conditioning equipment is located above the machines on the right and the air conditioner in the background, center. Automatic control of all functions and conditions within narrow limits will permit the NBS to obtain more reliable, accelerated weathering performance data on materials intended for outdoor use.

\* Technical Report 1509, National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.



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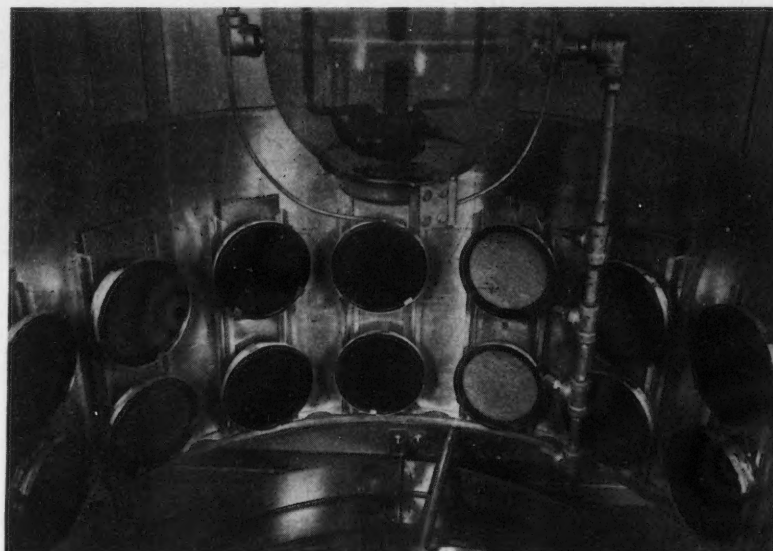
(Continued from Page 9)

are recorded by suitable instruments on each machine. Wiring circuits have been designed to take advantage of the 2 percent voltage control supplied the bureau.

The other hood encloses a modified commercial open-drum Atlas Weatherometer, two twin-are Weatherometers, and an Everready X-1A machine. These are controlled in a manner similar to that of the other machines.

An air conditioner of tremendous size could be required to control the temperature of the space around all 10 machines, which dissipate 39 KVA of energy. This temperature is therefore regulated by blending various amounts of outside corridor air (ranging from 15° to 35° C) with conditioned air at 25° ± 1° C. The resultant mixture is distributed to the machines in each hood by a 2000 cfm blower with a proportioning damper in its intake plenum. The blended air is distributed in turn to the vicinity of each machine by aluminum ductwork. Further conditioned air is drawn through a two-inch opening running along the floor of each of the hoods by an exhaust blower on the hoods which removes about 30 percent more air than is delivered by the ducts. In this way, the ambient air at each machine is maintained at 29 ± 4° C.

Water-conditioning equipment, located on a balcony above one of the hoods, delivers recirculated, deionized water with about 1 ppm of dissolved solids at any desired temperature be-



tween 4° and 25° C (± 1° C) to the six machines in that hood. At present, to introduce a cyclic thermal shock to asphalt exposure panels, the equipment is operating at 5° C and 25 pounds per square inch. The pH of the water is maintained by the deionizer at 6.2. Water for the other machines is delivered at room temperature and a pH of 6.0 by another deionizer. All machines can be operated with tap water if deionized water is not required.

Because accelerated durability testing of exterior coverings does not at the present time permit a quantitative correlation with actual weathering, the National Bureau of Standards has constructed a set of exposure decks on the roof of the laboratory that will hold 3000 test panels. Materials are thus exposed concurrently on the roof and in the controlled laboratory. Data from these studies should provide some statistical correlation between outdoor weathering in the Washington, D. C., area and in accelerated durability test-

Figure 2—Accelerated weathering tests at the National Bureau of Standards play an important part in the formulation of specifications for paints, asphalts, tars, etc. Here sample coatings are shown in test positions on the drum of one of the NBS weathering machines. The drum is revolved horizontally about the carbon arc (top), which produced the effect of several years of sunlight in a short time. Rain is simulated by water spray at right.

ing in each of the several types of machines.

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Decisions reached at the August 5 meeting of the National Association of Corrosion Engineers' executive committee have made available free advertising in *Corrosion* magazine under the headings: Positions Wanted and Positions Available.

Active members may use two consecutive insertions yearly consisting of not more than 35 words set in the standard text type.

Corporate members may use an unlimited number of advertisements consisting of not more than 35 words set in standard text type.

Firms not members but eligible to become corporate members also may use an unlimited number of advertisements consisting of not more than 35 words set in the standard text type.

Individual persons, not members, are not entitled to free advertising on any basis.

Advertisements of any nature or size or frequency which are different from or in excess of 35 words set in standard text type will be charged for at an appropriate rate, the minimum charge being \$5.00.

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New Members and  
Changes of Address

(Additions Through Feb. 27, 1951)

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DUGAN, JAMES A., Crane Equipment &  
Supply Co., 686 Massachusetts Ave., Cam-  
bridge, Mass.HIND, HARRY L., Thos. J. Hind Co., 125  
Magazine St., Boston 19, Mass.

## NEW JERSEY

SHIER, MANNOTH, National Molded Piping  
Distributors, 387 W. Side Ave., Jersey  
City 4, N. J.

## NEW YORK

REYS, JOHN, National Carbon Div., Union  
Carbide & Carbon Corp., 30 E. 42nd St.,  
New York, N. Y.SKINNER, S. D., National Gypsum Co., 325  
Delaware Ave., Buffalo, N. Y.SMITH, JAMES, Lithgow Corp., 36 W. 44th  
St., New York 18, N. Y.

## OHIO

COLYER, DAVID J., JR., The Durlon Co.,  
Inc., 450 N. Findley St., Dayton 1, Ohio.McGLOTHLIN, BRUCE B., JR., University of  
Cincinnati, 2829 Seloto St., Cincinnati 19,  
Ohio.PRENDERGAST, PHILIP J., The Cellete  
Co., 750 Rockefeller Bldg., Cleveland 14,  
Ohio.ROLFES, RICHARD P., Emerv Industries,  
4300 Carew Tower, Cincinnati 2, Ohio.

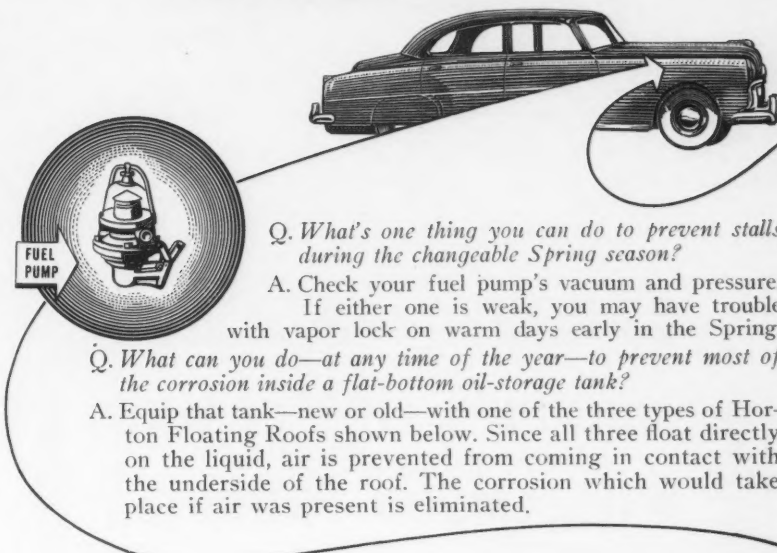
## OKLAHOMA

NEWELL, THOMAS M., Stanolind Oil &  
Gas Co., 1136 N. Lewis, Tulsa, Okla.RODGERS, CALVIN, Rodgers Engineering  
Co., 445 South Lewis, Tulsa 8, Okla.RODGERS, JOHN, Rodgers Engineering Co.,  
445 South Lewis, Tulsa 8, Okla.

## PENNSYLVANIA

APPLEMAN, GLEN, Pennsylvania Power &  
Light Co., 901 Hamilton, Allentown, Pa.DE GROOT, JOHN W., Tuscarora Oil Co.,  
Ltd., P. O. Box 22, Harrisburg, Pa.LANE, MONTIE J., H. C. Price Co., P. O.  
Box 6120, Philadelphia 15, Pa.MEYTEL, HARRY T., Royston Laboratories,  
Inc., Blawnox, Pa.SAUNDERS, WILLIAM F., Pittsburgh Coke  
& Chemical Co., 1720 Grant Bldg., Pitts-  
burgh, Pa.STEARNS, KENDALL P., Pittsburgh Pipe  
Cleaner Co., 133 Dahlem St., Pittsburgh  
6, Pa.

(Continued on Page 12)

Timely Tips about CARS  
and CORROSION

**Q.** What's one thing you can do to prevent stalls during the changeable Spring season?

**A.** Check your fuel pump's vacuum and pressure. If either one is weak, you may have trouble with vapor lock on warm days early in the Spring.

**Q.** What can you do—at any time of the year—to prevent most of the corrosion inside a flat-bottom oil-storage tank?

**A.** Equip that tank—new or old—with one of the three types of Horton Floating Roofs shown below. Since all three float directly on the liquid, air is prevented from coming in contact with the underside of the roof. The corrosion which would take place if air was present is eliminated.

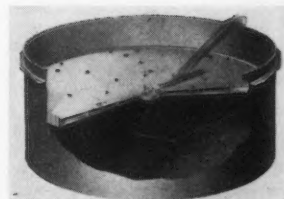
Here are some details about the differences between the Horton Floating Roofs shown at the right:

1. **Horton DOUBLE-DECK Floating Roof**—has two steel decks with insulating air space between. Air space divided into compartments to increase stability. The underside of the bottom deck is in contact with the liquid at all times.

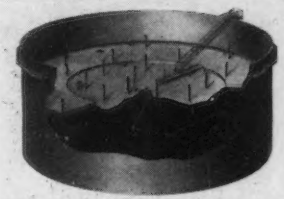
2. **Horton PONTOON Floating Roof**—Pontoon section covers half the area of the tank. Vapor caused by boiling when temperatures are high collects under center of roof, providing insulation against further boiling. Entire bottom of roof normally in contact with liquid.

3. **Horton PAN Floating Roof**—Provides maximum economy for tanks storing liquids of low volatility. The bottom of the deck is in contact with the liquid at all times.

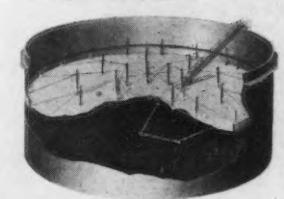
Beside cutting down corrosion inside the tank, all three types reduce the fire hazard . . . and stop filling and emptying evaporation losses. Where "boiling" losses are a factor, we recommend either a PONTOON or DOUBLE-DECK Floating Roof depending on the insulation needed to prevent boiling. Write our nearest office for information on all three types.



DOUBLE-DECK FLOATING ROOF



PONTOON FLOATING ROOF



PAN FLOATING ROOF

## CHICAGO BRIDGE &amp; IRON COMPANY

Atlanta 3 . . . . . 2137 Healey Building  
Birmingham 1 . . . . . 1552 North 50th Street  
Boston 10 . . . . . 1060—201 Devonshire Street  
Chicago 4 . . . . . 2119 McCormick Building  
Cleveland 15 . . . . . 2248 Guildhall Building  
Detroit 26 . . . . . 1561 Lafayette Building  
Houston 2 . . . . . 2159 National Standard Building

Los Angeles 17 . . . . . 1552 General Petroleum Building  
New York 6 . . . . . 3328—165 Broadway Building  
Philadelphia 3 . . . . . 1661—1700 Walnut Street Building  
Salt Lake City 4 . . . . . 563 West 17th South Street  
San Francisco 4 . . . . . 1572—200 Bush Street  
Seattle 1 . . . . . 1363 Henry Building  
Tulsa 3 . . . . . 1640 Hunt Building  
Washington 6, D. C. . . . . 1640 Hunt Building

Plants in: BIRMINGHAM, CHICAGO, SALT LAKE CITY, and GREENVILLE, PA.



## New Members—

(Continued from Page 11)

STREATER, FLOYD E., Gulf Oil Corp., Refinery Technology Laboratory, Girard Point, Philadelphia, Pa.  
VANDENBURGH, DAVID G., Aluminum Co. of America, Aluminum Research Laboratories, New Kensington, Pa.  
WAGNER, JOHN, JR., Keystone Pipe Line Co., 260 S. Broad St., Philadelphia 1, Pa.

### TEXAS

CATTS, GORDON R., Eggelhof Engineers, P. O. Box 3276, Corpus Christi, Tex.  
GOLDBERG, GERALD J., Gulf States Asphalt Co., Box 508, South Houston, Tex.  
KOZAKIS, ACHILLES, 7463 Brockley Lane, Houston 17, Tex.  
LANE, H. S., Crown Central Petroleum Corp., P. O. Box 1759, Houston 1, Tex.  
MCKINNEY, T. BURNS, Dowell, Inc., Box 1858, Midland, Tex.

NELSON, LLOYD A., JR., Freeport Sulphur Co., P. O. Drawer A, Freeport, Tex.  
SILBERSTEIN, MILTON L., 1607 Francis, Houston 4, Tex.

### WISCONSIN

BURNSIDE, CARL B., Kimberly-Clark Corp., Neenah, Wis.  
LENDVEI, JOHN W., Chain Belt Co., 4500 W. Greenfield, Milwaukee, Wis.

### CANADA

BLACKHALL, L. C., 1962 Jane St., Weston, Ontario, Toronto, Canada.

### VENEZUELA

CHUCK, FRANK, Creole Petroleum Corp., Cabimas, Estado Zulia, Venezuela, S. A.

## CHANGES OF ADDRESS

(Old Address Follows New in Parenthesis)

### CALIFORNIA

SULLIVAN, DAVID N., 570 W. Stocker St., Glendale 2, Calif. (Electro Rust-Proofing Corp.—N. J., 68 Peachtree St., N.W., Atlanta, Ga.)

## DISTRICT OF COLUMBIA

SPARKS, ROBERT E., LT. COMDR., LCDR., U. S. Naval Dept., Rm. 1046, Bldg. T-3, Washington 25, D. C.  
(SPARKS, ROBERT E., LT. COMDR., CEC, U. S. Naval Construction, Battalion Center, Port Hueneme, Calif.)

### ILLINOIS

KOLZOW, CLARENCE R., 400 Prospect St., Elmhurst, Ill. (Western Electric Co., 400 Prospect St., Elmhurst, Ill.)  
PARSON, ROBERT A., Pullman-Standard Car Mfg. Co., Res. & Dev., 10901 Cottage Grove Ave., Chicago, Ill. (Pullman-Standard Car Mfg. Co., Res. & Dev., 1414 Fields St., Hammond, Ind.)  
STROTHMAN, E. P., Route No. 2, Old Dundee Rd., Barrington, Ill. (301 S. Michigan Ave., Chicago 4, Ill.)

### KANSAS

KAUFFMAN, DAVID S., Sinclair Pipe Line Co., Products Pipe Line, Sinclair Bldg., Independence, Kan. (Sinclair Refg. Co., Products Pipe Line, Box 460, Independence, Kan.)  
UNRUH, EARL W., Sinclair Pipe Line Co., Sinclair Bldg., Independence, Kan. (Sinclair Refining Co., Sinclair Bldg., Independence, Kan.)

### LOUISIANA

BRANTON, JAMES A., 717 Kirby, Shreveport, La. (1025 Gill St., Columbia, Miss.)  
McMILLAN, W. A., JR., 412 Ethyl St., Lake Charles, La. (121 Virginia St., Waxahachie, Tex.)

### MARYLAND

FARRAR, WALTER B., 10211 Connecticut Ave., Kensington, Md. (5011 Elm St., Bethesda, Md.)

### MISSISSIPPI

SWINDOLL, ROBERT E., United Gas Corp., Laurel, Miss. (United Gas Corp., P. O. Box 1138, Jackson, Miss.)

### MISSOURI

BERRINGER, JOHN C., Panhandle Eastern Pipe Line Co., 34 W. 57th Terrace, Kansas City, Mo. (34 W. 57th St., Kansas City, Mo.)  
EBERT, RAYMOND E., 1617 Kenilworth Dr., Brentwood 17, Mo. (Fairbanks, Morse & Co., Westco Works, 4301 S. Spring Ave., St. Louis 16, Mo.)

### NEW JERSEY

BEGGS, CHARLES W., Public Service Electric & Gas Co., 80 Park Place, Rm. 5103, Newark, N. J. (Public Service Electric & Gas Co., 80 Park Place, Rm. 2169A, Newark, N. J.)  
OBERMANN, WALTER, 333 Hillside Ave., Leonia, N. J. (Electro Rust-Proofing Corp., 1 Main St., Belleville, N. J.)

### NEW MEXICO

BLACKMAN, BRUCE A., LT., Box 653, Tulsa, N. Mex. (Dowell Inc., 524 Kennedy Bldg., Tulsa, Okla.)  
RUSSELL, JOHN C., 3114 42nd Place, Sandia Base, Albuquerque, N. Mex. (3272 47th St., Sandia Base, Albuquerque, N. Mex.)

### NEW YORK

MEYER, PHILIP A., Nicolet Industries, Inc., 70 Pine St., New York, N. Y. (Gama Industries, Inc., 70 Pine St., New York, N. Y.)  
SNELL, CLARK A., Nicholson & Galloway, Inc., 205 W. 13th St. New York 11, N. Y. (Nicholson & Galloway, Inc., 426-28 E. 110 St., New York 29, N. Y.)

### OHIO

SEVERANCE, WESLEY A., The Cellcote Co., 4832 Ridge Rd., Cleveland 9, Ohio (The Cellcote Co., Rockefeller Bldg., Cleveland, Ohio)  
SMITH, WILLIAM E., JR., The Cellcote Co., 4832 Ridge Rd., Cleveland 9, Ohio (The Cellcote Co., 750 Rockefeller Bldg., Cleveland 13, Ohio)  
WALKER, JAMES D., Sinclair Pipe Line Co., 139 N. State St., Marion, Ohio (Sinclair Refg. Co., Products Pipe Line, 139 N. State St., Marion, Ohio)  
WATTS, ADMIRAL A., 728 Alton Ave., Columbus 3, Ohio (1385 E. 23rd Ave., Columbus 11, Ohio)  
ZANE, MAX, c/o James N. Dugan, 2538 Hackberry St., Cincinnati, Ohio (U. S. Army, Granite City, Engineer Depot, Granite City, Ill.)

### OKLAHOMA

EVANS, DWIGHT J., Engineering Test Service, Rm. 1107, Amer. Airlines Bldg., 910 So. Boston, Tulsa, Okla. (Engineering Test Service 2112 East 15th St., Tulsa, Okla.)


(Continued on Page 14)

**THE PIG WITH THE POKE** **CLEANS PIPE LINES**

# 5000 PIPE LINE CASINGS

INSTALLED IN 1950 WITH THESE

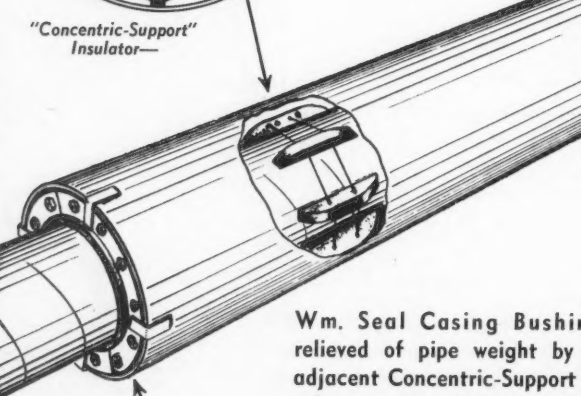
# WILLIAMSON PRODUCTS



PIPE  
CENTERED  
IN CASING

Improved "Concentric-Support" Insulators\* now have 50 to 60% more Support Blocks.

Utilize high voltage of welding machine for positive proof of pipe to casing insulation.



"Concentric-Support" Insulator—

Wm. Seal Casing Bushing

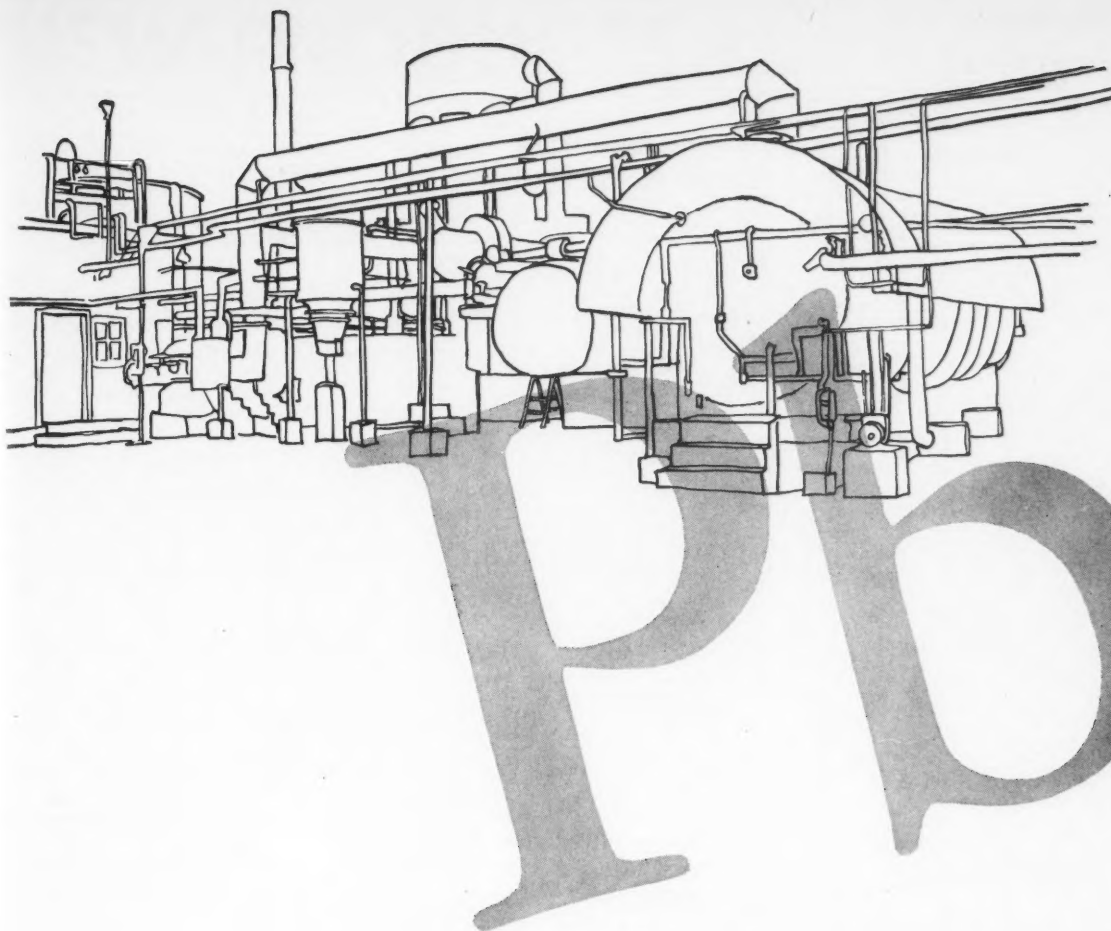
Wm. Seal Casing Bushings relieved of pipe weight by an adjacent Concentric-Support Insulator now seals casing better than ever before.

Write for NEW 1951 Installation Booklet, 149-A

\*Patents Pending

# T. D. Williamson, Inc.

TULSA 9, OKLAHOMA



## USING SULFURIC ACID?

Under many pressures, concentrations and temperatures, lead is the ideal material for handling sulfuric acid. It safely handles other corrosives as well.

For fabrication, lead is unique. Sheet lead can be welded, or "burned", to form a continuous lining; it can be bonded to another metal. Lead can be cast, die cast or pressure molded; extruded as pipe or other shapes; fastened by welding, flanging or bolting. Once installed, lead chemical equipment is easily repaired with a welding torch.

Because of the many complex factors in any corrosion problem, expert advice is usually advisable. For complete technical assistance, see Federated first. For lead products, think of ASARCO Brand lead pipe, lead sheet, and lead fittings.

Available in all standard sizes and forms through Federated's 22 sales offices across the country.

*Federated Metals Division*



AMERICAN SMELTING AND REFINING COMPANY • 120 BROADWAY, NEW YORK 5, N. Y.

## New Members—

(Continued from Page 12)

GRISWOLD, T. N., Continental Oil Co., P. O. Drawer 1267, Ponca City, Okla. (Continental Oil Co., Refinery Office, Ponca City, Okla.)

### PENNSYLVANIA

FISHER, EARLE E., 615 Glenfield Ave., Glenolden, Pa. (Gulf Oil Corp., Girard St., Philadelphia, Pa.)

DePAUL, D. J., Westinghouse Electric Corp., Atomic Power Div., P. O. Box 1468, Pittsburgh 30, Pa. (Westinghouse Atomic Power Div., Homestead, Pa.)

### TEXAS

DAVIS, BILLY H., 4535 Verone, Bellaire, Tex. (1212 Smallwood Ave., Houston 12, Tex.)

DIRKS, RICHARD W., P. O. Box 71 Tuleta, Tex. (Union Producing Co., P. O. Box 711, Beeville, Tex.)

EXUM, JAMES P., JR., Apt. 1, 990 14th St., Beaumont, Tex. (United Gas Corp., P. O. Box 2830, Beaumont, Tex.)

GRANT, WHEELER H., Central Power & Light Co., Box 997, Laredo, Tex. (Central Power & Light Co., P. O. Box 2121, Corpus Christi, Tex.)

HIGGINS, J. D., JR., J. D. Higgins Co., 822 Nell P. Anderson Bldg., Fort Worth 2, Texas (J. D. Higgins Co., 804 Nell P. Anderson Bldg., Fort Worth, Tex.)

KEHN, G. RAY, 304 Pine St., Orange, Tex. E. I. duPont de Nemours, Inc., P. O. Box 2027, Sabine River Wks., Orange, Tex.)

NEILON, C. R., The National Supply Co., P. O. Box 9163, Houston 11, Tex. (The National Supply Co., P. O. Box 2616, Houston 1, Tex.)

SNEDAKER, DELBERT G., P. O. Box 7119, Houston 8, Tex. (c/o W. M. Wiley, Box 600, Wichita Falls, Tex.)

### WEST VIRGINIA

ZIMMERER, ROBERT I., Westvaco Chemical Div., Food Machinery & Chem. Corp., Drawer 8127, South Charleston 3, W. Va. (Westvaco Chemical Div., Food Machinery & Chem. Corp., Drawer J, South Charleston 3, W. Va.)

### CANADA

HORNE, ALBERT N., Trans-Northern Pipe Line Co., P. O. Box 400, Terminal "A", Toronto 1, Ontario, Can. (Trans-Arabian Pipe Line Co., P. O. Box 1348, Beirut, Lebanon)

## Houston University Section Holds Election

Members of the Houston University Student Section of NACE adopted a distinguishing key as a symbol of membership at a meeting March 9. The key, approximately  $\frac{3}{4}$ -inch long by  $\frac{3}{8}$ -inch wide has a simulated ruby stone and a replica of the association emblem affixed. The official name of the section is "The University of Houston, Student Section, Alpha Chapter, Junior members of NACE."

This first student section of the association was organized about 10 months ago under the guidance of John P. Roberts, associate professor of metallurgy, who is senior faculty adviser of the group. The section's articles of organization and by-laws were approved by South Central Region trustees, and the activity of the organization resumed with 20 members in good standing this spring. The Houston University Council of Student Government considered the recognition of the organization as an authorized organization on the campus and advised the university's dean of men of its unanimous approval, who in turn notified the section January 25.

Current officers are W. G. Boyd, Jr., chairman; J. A. Quinn, vice-chairman; J. L. Richardson, treasurer; B. J. Armstrong, secretary. Members are, in ad-

dition to the above, Louis D. Allen, Charles A. Bammel, John V. Bowman, Chelsey L. Brock, Sidney C. Farmer, Charles L. Gerlovich, Donald P. Kedzie, George J. Klarman, Meyer Klein, M. F. Krch, Leo S. Mitchell, Guy C. Mock, Edward J. Mulvaney, James G. Nickerson, Seymour Proskowitz, Anthony Saia, Glenn C. Scott, James B. Thompson, Teddy L. Wickens.

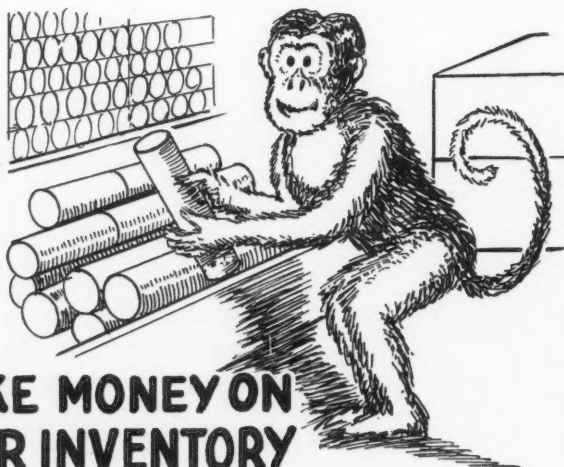
## Lubrication Engineers

The 1951 National Convention of the American Society of Lubrication Engineers will be held in Philadelphia, April 16-18, 1951, at the Bellevue-Stratford Hotel. Among the items scheduled on the technical agenda is an address by H. B. Carpenter, Esso Standard Oil Co., on "Rust Preventives."

Notices of meetings to be held by NACE subdivisions will be carried in the "NACE Calendar" if received in time.

### MEMBERSHIP CARDS AVAILABLE

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.



## MAKE MONEY ON YOUR INVENTORY

Service Engineers insulating bushings are packaged in rolls of 10 and in cartons of 600-1000, depending on size of bushings. You can count 5000 bushings in less than three minutes.

All bushings are ring and plug gauged with standard pipe gauges to assure you of a perfect product.

CALL . . . WIRE . . . WRITE

**SERVICE ENGINEERS, INC.**

Manufacturers of Industrial Plastic Products

FIRST NATIONAL BANK BLDG.

FORT WORTH, TEXAS



# NEW PRODUCTS — Materials — Service — Literature

**Silver** added to solder in a small percentage permits a marked reduction in the percentage of tin content, the newly formed Metals Conservation Committee of Federated Metals Division, American Smelting & Refining Co. announces. The company's "ST (Save Tin) Solders" incorporating small percentages of tin result in no loss of working efficiency and the cost is less than that for the alloys they are designed to replace. The committee expects to work continuously on projects to conserve critical non-ferrous materials.

**Prufcoat Metal Reactive Primer P-10**, according to manufacturers Prufcoat Laboratories, Inc., 63 Main Street, Cambridge, Mass., may be applied to damp or dry metal surfaces that are reasonably rust-free and have been degreased. The primer reacts with the metal to dry excessive moisture, inhibit further rusting and furnish a chemically treated surface to which "A" series Prufcoat will bond securely, the manufacturers say. Copies of Prufcoat Technical Bulletin 012 giving further details of the material may be secured on request.

**Piping Engineer's Dimensional Data Card**, an 8½ x 11 inch varnished card, gives dimensions of welding fittings on one side, including wall thickness and essential dimensions for all types of fittings for every nominal pipe size from ½ through 30 inches and on the other essential dimensions of forged steel flanges in all weights for nominal pipe sizes ½ through 24 inches. Material detailed is that manufactured by Taylor Forge and Pipe Works, P. O. Box 485, Chicago 90, Ill. from which copies may be secured on request.

**All-State No. 3 Cast Iron** (copper coated) Welding and Brazing rod which uses less of hard to get nickel base welding alloys is suggested by manufacturers All-State Welding Alloys Co., Inc., 273 Ferris St., White Plains, N. Y. for salvage and production as a substitute for rods using more critical materials. Applied with flux and a neutral oxy-acetylene flame, it does not require melting base metal or "puddling the weld."

**"dag"** Colloidal Graphite dispersions, colloidalized electric furnace graphite in an appropriate fluid carrier, when deposited on parts subsequently brought into contact with one another helps prevent sticking, galling and freezing of parts and under some conditions inhibits corrosion. After evaporation of the carrier a graphoid film consisting of microscopic particles of graphite remains on the treated surfaces. The material, a product of Acheson Colloids Corp., Port Huron, Mich. is explained in Bulletin No. 427.

**Nooter Corp.**, 1400 S. Second St., St. Louis 4, Mo. will send on request written on a Company letterhead its new easy-to-read slide rule type Flange and Coupling Selector. It lists such facts as OD of flange, thickness, OD of raised face, number of holes, diameter of holes,

bolts, bolt circle for Series 15 and 30 flanges; average sizes of standard, extra heavy, 3000-lb. and 6000-lb. couplings and includes a convenient pipe standard table.

**Gulf No-Rust No. 6**, an addition to the Gulf Oil Corp. line of anti-rust materials will produce a dip coat not over 8 thousandths of an inch at 70 degrees F and will dry sufficiently in four hours for handling. Recommended for protection of metal against corrosion in indoor or outdoor exposure during domestic and overseas shipment, and for indoor or outdoor storage for long periods, the material is of the thin film type. It has no tendency to settle or separate in storage, provides approximately 390 square feet of coverage per gallon, and because of excellent adhesion when dried will not crack, chip, scale or disintegrate at temperatures down to 0 degrees F nor flow at temperatures up to 190 degrees F. Suitable for brush, spray or dip application it is removed readily with stoddard solvent, kerosene or similar petroleum solvents.

**Wilbur & Williams Company** has moved to new and larger quarters at 130 Lincoln Street, Boston, Mass.

**Gra-Lite** safety clothing, Geon resin impregnated materials of light weight,

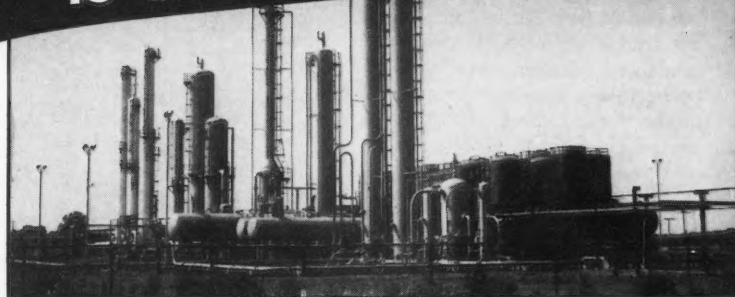
gray color, affords worker protection against the action of red fuming nitric acid and other inorganic acids, in addition to alkalis, salts, hydrocarbons, amines and strong oxidizing agents. The coating will not support its own combustion, and seams are lapped with chemically resistant thread and fused to form a continuous coated surface. Standard Safety Equipment Co. of Chicago is manufacturer.

**Newage International, Inc.**, 521 Fifth Ave., New York 17, N. Y. offers Bulletin ET describing its new portable Ernst Direct Reading Metal Hardness Tester. Immediate on-the-job readings on all types of metals are possible.

**"Controls Guide"** embodying compact digests of orders, prices, priorities, limitation or production directives issued by government in connection with war production regulations has been revived and is available from The Journal of Commerce, New York City.

**Atlatic 58**, a hot melt corrosion resistant plastic with outstanding adhesion to concrete and steel is a new product of Atlas Mineral Products Co. The company also has introduced Conductoplast, a castable resin cement electrical conductor which exhibits practically no voltage drop. The material,

## PREVENTIVE MAINTENANCE IS ESSENTIAL TODAY!



### CONTROL SCALE and CORROSION in ENGINE JACKETS, COMPRESSORS, COOLING TOWERS—Wherever Water Is Used

Now, more than ever before, it is necessary to increase the efficiency and life of equipment by maintaining scale-and-corrosion-free water-side surfaces. Wright Chemical Engineers can solve your water-conditioning problems quickly and economically.



### WRIGHT CHEMICAL CORPORATION

Specializing in Water Conditioning

GENERAL OFFICE AND LABORATORY

619 West Lake Street, Chicago 6, Illinois

OFFICES IN PRINCIPAL CITIES

Sole Distributor of Nelson Chemical Proportioning Pumps

## New Products—

(Continued from page 15)

which can be plated, has a tensile strength of 1500 psi, compression strength of 15,000 psi and excellent adhesion to ceramic surfaces. Atlas also has developed a non-conductor called Resistoplast. Pilot plant quantities are available from the company, 42 Walnut St., Mertztown, Pa.

Hagan Corporation has established a Chicago district office at 1463 Monadnock Bldg., 53 W. Jackson Blvd., Chicago 4, Ill.

Corrosion Control Coatings is the title of a 12-page illustrated folder containing information about its vinyl base coatings for exteriors and tank linings

issued by Casey & Case Coating Co., P. O. Box 151, Maywood, Cal.

**Econalloy Heat Exchangers**, a product of Martin-Quaid Co., 1815 West Sedgley Ave., Philadelphia 32, Pa. are described in Product Data Sheet No. 9-1. The heat exchangers, of the tube within a tube type embody features conducive to long life, the company claims. An insert flange of the alloy material is welded to the carbon steel flange and the outer tube of the exchanger. The inner tube is expanded into specially prepared serrations in the inside diameter of the flange insert.

**Silica-Graphite**, a microscopic graphite crystal combined by nature with silica, is recommended as a pigment for industrial primers and finish paints by Protective Coatings Division, Joseph Dixon Crucible Co., Jersey City, N. J.

Coatings combine the graphite pigment with red lead, chromate, red oxide, aluminum and other coloring agents to produce a wide range of colors. The coatings are recommended for almost all materials, and they have special value as high-temperature coatings, manufacturers say. The graphite crystal is not affected by ultra-violet or infrared rays, acids, alkalis or heat and application is limited only by vehicles and solvents used.

## PERSONALS

**Layton C. Tuggle**, secretary-treasurer of Houston Section returned to duty with the Air Force March 1. A World War II veteran, he was an active reservist as navigator at Ellington Field, Texas. Mr. Tuggle, corrosion engineer at the Houston refinery of Shell Oil Co. has been active in association affairs and has done extensive work on underground corrosion and cathodic protection of refinery installations.

**Donald C. Brewer**, treasurer of Wright Kay & Co. has been named treasurer of the Hinchman Corp. **Leonard P. Schaefer**, corrosion engineer, has been named assistant general manager of the firm. **James F. Hirshfeld**, vice-president and general manager and **E. R. Shepard**, senior corrosion engineer have left on an overseas assignment for the navy.

**R. R. Donaldson** and **Dr. Everett P. Partridge** have been named to the board of directors of Hagan Corp., Pittsburgh and its subsidiaries.

**Sidney V. Smith** has been appointed to the sales and technical staff of Napko Paint & Varnish Works, Houston, Texas. He is a Texas A. & M. College graduate.

**Robert Crooks Stanley**, chairman of the board of directors of The International Nickel Co., of Canada, Ltd., died February 12.

**Paul W. Bachman** has been named director of research for Davison Chemical Corp., Baltimore, Md.

Personnel changes at Dowell Incorporated offices include: **Marshall L. Stirling**, salesmanager of the petroleum division becomes head of the Fort Worth office; **Roy W. Allen** and **Harold L. Ellis** from San Angelo and Odessa respectively, have been promoted to sales engineers and will be at the Fort Worth office. **Herbert A. Koch**, formerly head of the Fort Worth office will establish a general office sales branch at Houston.

**Donald F. Deakin** has been named product director in charge of water and sewer materials for Atlas Mineral Products Co. and **Earl Erich** has been named product director for linings and coatings.

**John W. Nestor** has been named assistant manager of the finishes division of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

THE BEST PROTECTION AGAINST CORROSION COSTS  
LESS IN THE LONG RUN . . . . .

# TYGON

## CORROSION-RESISTANT PLASTIC

# PAINT

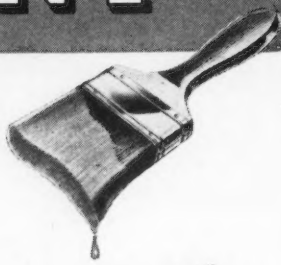
**H**ALFWAY protection is worse than none where corrosion is a problem. Ordinary paints provide only a shield behind which corrosion goes on, uninterrupted. Be sure. Play safe. Protect your plant and its equipment with the paint proven over a 10-year period as the paint impervious to attack by most acids and alkalis.

Tygon corrosion-resistant plastic Paint is made of chemically inert plastics. It air dries quickly . . . forms a tough, durable, tight-adhering plastic film that will not support combustion . . . that will resist impact and chipping . . . that will provide effective protection against corrosive fumes and gases long past the life of even the best industrial paints.

Write today for your free copy of Bulletin 709.

**U. S. STONEWARE**

Akron 9, Ohio



RESISTS ACIDS,  
ALKALIES, WATER,  
ALCOHOL

NON-OXIDIZING,  
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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

# NACE Growth in All Areas During Year Is Emphasized



**NACE OFFICERS**—Officers whose terms started Friday, March 16, are, left to right, Mars G. Fontana, Ohio State University, Columbus, Ohio, vice-president; N. E. Berry, Serval, Inc., Evansville, Ind., president, and Russell A. Brannon, Humble Pipe Line Company, Houston, Texas, treasurer. This photograph was taken at the annual banquet, Hotel Statler, New York City, during the Seventh Annual Conference.

By VANCE N. JENKINS

On this occasion, the general business meeting opening the annual conference and exhibition of the National Association of Corrosion Engineers, it has become customary for the president of the association to review the progress made by it in the previous year during which he has held office. It also is customary at this time for the executive secretary, the treasurer and the chairmen of the five standing committees provided for by the Articles of Organization to present reports covering the activities of their offices or committees for the previous year. These standing committees are the Publications Committee, the Regional Management Committee, the Technical Practices Committee, the Policy and Planning Committee, and the Inter-Society Corrosion Committee. The Membership Control, the Advertising, the General Conference and Local Arrangements Committee chairmen also will present accounts of their committees' achievements during the past year.

It is evident from the nature of these committees that the reports of their chairmen plus those of the executive secretary and the treasurer of the association will give a rather complete account of association activities for this past year and that the report of the president must necessarily be more or less a summary of the principal achievements pointed out by them. For that reason it will be brief in order not to duplicate too great a portion of the reports which follow.

### Membership

On January 1, 1950, the association had 2133 members. During 1950, 587 new members were added while 226 members were lost for various reasons such as voluntary resignation, failure to pay dues, being called into military service, etc. The result was that at the close of business on December 31, 1950, the total membership of the association was 2494. This is a net gain during the year 1950 of 361 members. This is a 17 percent increase in membership and that in turn is only one and a fraction percent less than the increase in membership the previous year. This rate of increase, if plotted as a curve showing percentage increase in membership for each year of the association's existence, indicates the association membership has by no means reached a leveling off point, but that further increases may be expected for a number of years' time to come. This prediction takes full account of the existing emergency during which an increasingly larger number of the association's younger members undoubtedly will be called into the armed services of the nation. A breakdown of the total membership shows 2163 active members, 289 corporate members and 42 junior members. These totals show similar percentage gains occurred in each membership class.

(Continued on Page 18)

## Donovan Praises Committees for Smooth Functioning of Convention Arrangements

Credit for the smooth functioning of the Seventh Annual Conference and Exhibition held March 13-16 at Hotel Statler, New York City was given to committee members by L. B. Donovan, general chairman. Mr. Donovan cited the record registration of 1285, which was 343 more than the previous record set at St. Louis in 1950, and the registration of 130 women for various functions of the women's program as outstanding achievements. It was indicated more than 200 participated in the various activities of the women's program, and Mr. Donovan praised the work of Mrs. Beatrice Bailey who acted as chairman of arrangements for the women's program.

Pre-registration, instituted for the first time at an association national meeting, was credited with a large part in the smooth functioning of the registration procedure and the relative lack of congestion. Further, cooperation of Hotel Statler management was excellent, Mr. Donovan reported.

### TV Program Broadcast

Rowland English, publicity chairman, with the assistance of the hotel publicity staff, arranged for the filming of a program for broadcast over Dumont Television network. The program involved presentation of the advantages of the Shell Development Company's vapor phase inhibitor as a substitute for the grease preservative customarily used on ordnance to protect it against corrosion in storage and transit.

A press conference also was held at which F. L. LaQue, formerly president of the association, Dr. A. Wachter, of Shell Development Co., and Major P. E. Foster of the Air Force, Washington, D. C. were interviewed. This conference was reported in several New York periodicals.

### Booths Well Attended

Exhibits were given close attention, most exhibitors queried reported. The new NACE booth attracted considerable attention and Central Office personnel manning it was kept busy answering questions about the association and its publications. A number of application blanks were handed in during the conference and numerous others took blanks away to be filled in and returned later. Many orders were accepted for NACE publications.

### Round Tables Crowded

Over 400 were present at the Pipe Line Round Table Friday morning and a somewhat smaller number at the concurrent General Corrosion Problems Round Table.

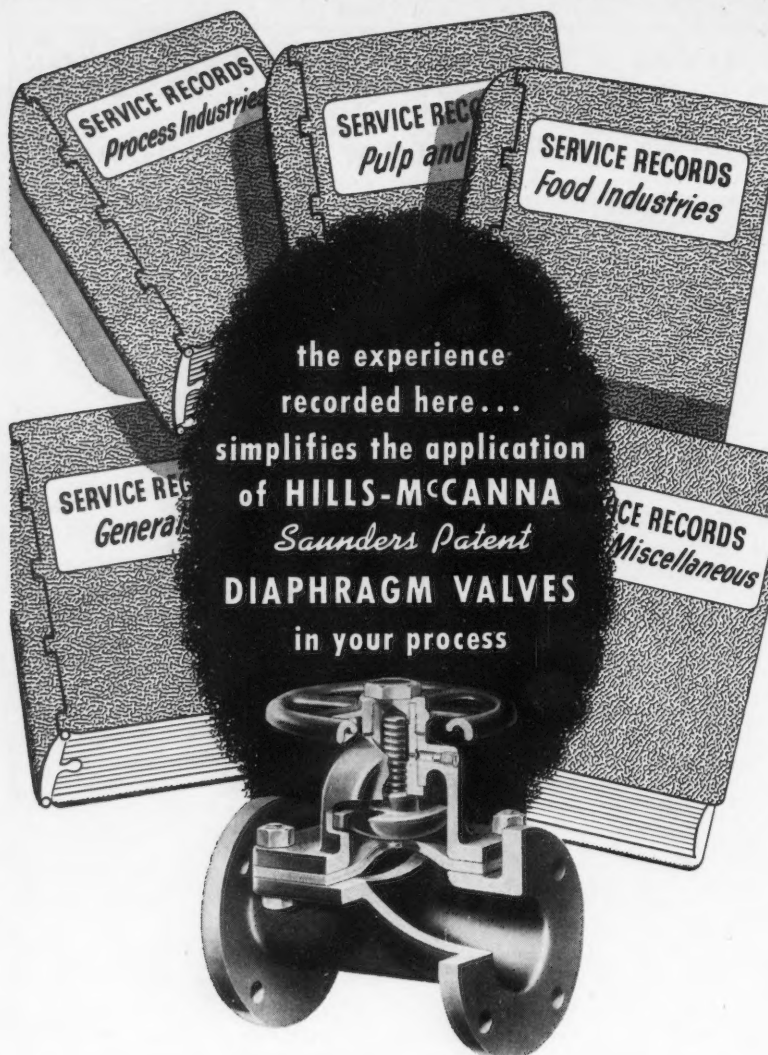
Reporters were present at all technical sessions except the round tables to take records of discussors so remarks may be collected for publication in CORROSION.

## Diehlman Vice-Chairman Of Editorial Committee

George Diehlman, who is with National Lead Company Research Laboratories, Brooklyn, New York has been named vice-chairman of the editorial review committee of the association in an organizational change decided on by the committee during the Seventh Annual Conference in New York. Mr. Diehlman will become chairman of the committee next year, the present chairman F. N. Alquist, retiring from the committee. A new vice-chairman will be named and a new member added to the committee each year.

This change was adopted because of the feeling the work of the editorial review committee should not be expected of the same persons indefinitely.





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## NACE Growth—

(Continued from Page 17)

### Finances

The association continued to grow not only in size but also in total assets and in the amount of business transacted. This is illustrated by the following comparisons. In 1949 the total revenue of the association was \$125,957.62 while total expense was \$113,138.48, leaving an excess of revenue over expense of \$12,819.14. This past year, 1950, the total revenue was \$135,088.95, total expense of \$119,513.84 and excess of revenue over expense was \$15,575.11. At the end of the year, December 31, 1950, the total assets of the association were \$81,165.67 as compared to \$52,917.74 on the same date the previous year, 1949, and to \$28,247.93 two years before on December 31, 1948.

### Publications

It should be pointed out that publications accounted for slightly more than half of the excess of revenue over expense this past year. This is by far the best showing publications has made and Miss Ivy Parker, chairman of the Publications Committee, and the editorial staff as well deserve praise for it.

The paid circulation of CORROSION magazine increased from an average of 2758 copies per month in 1949 to 3228 copies per month in 1950; a total of 44,748 copies being printed in 1950 as compared to 36,668 copies in 1949. This increase percentagewise is the same as the percentage increase in association membership. However, the gross advertising income for 1950 increased by a greater amount; namely, 22 percent over that of 1949, the figures being \$57,679.30 versus \$47,212.50, an increase of \$10,466.80.

Nearly twice as many reprints of articles appearing in CORROSION were sold in 1950 as in 1949. It is noteworthy that reprint costs were reduced from an average of 10.8 cents to 5.8 cents per copy during the past year.

Other publications achievements this past year were issuing of the Volume 6 index and the five-year index, both of which were tabular cross-referenced. In addition, the work of planning the new abstract service was completed and a sufficient number of promises of subscriptions to the service obtained to guarantee its success. The principal change in the format of CORROSION magazine introduced this past year was that of numbering the abstract pages serially.

### Sectional Activities

The growth in the number of local sections has been very gratifying to the officers of the association since it is believed that a build-up of strong local sectional activities will do much to guarantee continued healthy growth of the association. As of December 31, 1949, there were 16 local sections organized and operating. With the formation of the Detroit local section now in progress, this number will be increased to 22. The local sections formed this past year are the Western New York, Cincinnati, New Orleans-Baton Rouge, Los Angeles, and the University of Houston Junior Section.

### Technical Practices Committee

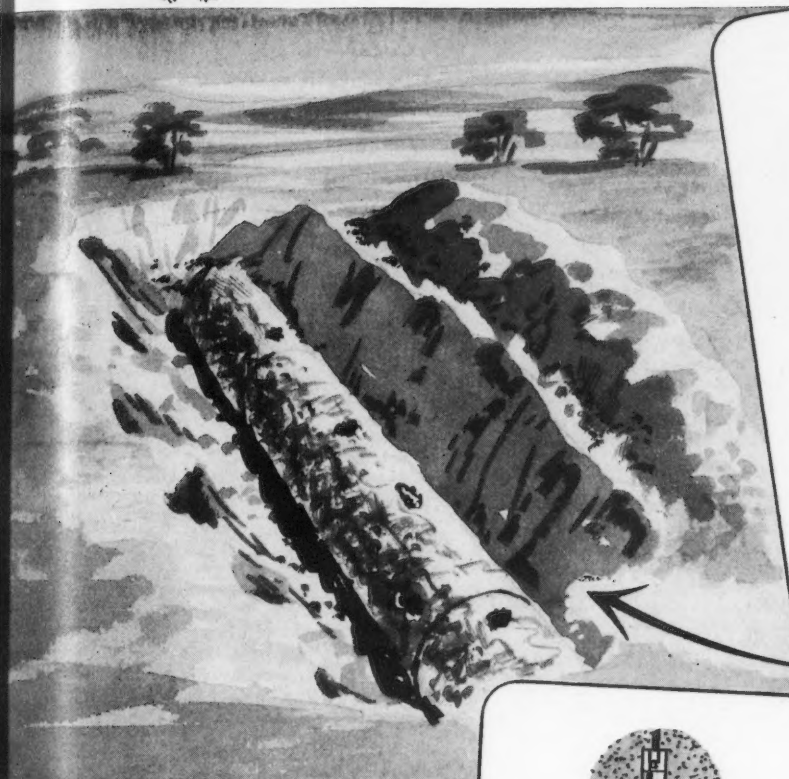
The Technical Practices Committee has continued to increase its field of (Continued on Page 20)



Who000000 ...

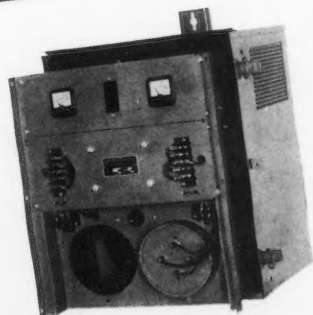
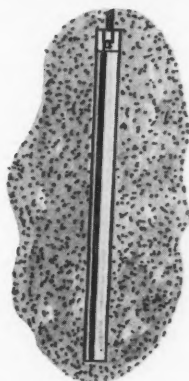
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Distributors for General Electric and National Carbon Cathodic Protection Products • Offices in Principal Cities

## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

### NACE Growth—

(Continued from Page 18)

activity by expanding the number of its subcommittees. Additional reports of its subcommittees have been published and the nature of these reports reflects the increasing importance of the studies undertaken as well as the growth of the association's prestige in the field of corrosion literature. Details of this committee's activities will be given by the report of its able chairman, Dr. Mars Fontana. However, it is believed it should be mentioned now that The International Nickel Company's offer of a \$5000 grant for financing theoretical research on corrosion processes involving hydrogen sulfide has been accepted by the officers of the association. This money will be expended under the direction of Technical Practices Committee subcommittee 1-G for research to be carried on at a university yet to be selected on the problem of determining the cause or mechanism responsible for sulfide corrosion cracking of steel.

#### Policy and Planning Committee

During the past year the Policy and Planning Committee, under the direction of its chairman, Mr. E. P. Noppel, has been very active. Since January 1, 1950, the association has been operating under the new and revised Articles of Organization and By-Laws which were drawn up originally by this committee. During this period of time it has been necessary



WALTER F. ROGERS

With Gulf Oil Corp, Houston, Texas, has accepted the general chairmanship of the 1952 annual meeting of the National Association of Corrosion Engineers, which is to be held at Galveston, Texas, during March.

for the committee to keep in very close touch with the details of the operation of the association in order that firsthand knowledge could be gained of any troublesome situations arising as a result of the operating procedures required by either the new Articles of Organization or the By-Laws and prompt steps be taken to prepare proposed revisions for them, the adoption of which by the membership or Board of Directors, as required, would prevent development of difficulties in the future. This committee is doing an excellent job and deserves the thanks of the entire membership of the Association.

#### Regional Management Committee

Working in close cooperation with the Policy and Planning Committee is the Regional Management Committee under the chairmanship of another of our elder statesmen, Mr. L. A. Baldwin. This committee is endeavoring to prepare proposed procedures for the operation of regions and sections which will not conflict with national association policies yet permit sufficiently independent operation to result in efficient and timely administration of regional and sectional affairs. In this connection a major problem confronting this committee is the working out of a satisfactory procedure for the financing of local sectional activities and determining the amount and type of sectional expenditures for which the sections should be reimbursed by the treasurer of the national Association. Since conditions vary so greatly among the different regions and sections, a solution to this problem which will satisfy all concerned and yet not be wasteful of association funds has not proved easy to accomplish.

#### Inter-Society Activities

The Inter-Society Corrosion Committee, under the chairmanship of Mr. Sam Tour, has continued its cooperative

work with other societies interested in corrosion and its control. At the present time this committee is involved in working out relations with foreign societies desirous of cooperating with the National Association of Corrosion Engineers in various ways.

#### Educational

It is believed a word should be said regarding the progress made by the Education Committee under the chairmanship of Dr. Norman Hackerman. This committee arranged for a Short Course in Corrosion held this winter at Stevens Institute. As a result of negotiations begun last year, the Massachusetts Institute of Technology has announced a similar course in corrosion to be held later in the year. This past September Dr. Hoxeng conducted a short course in corrosion at the Case Institute of Applied Technology which was eminently successful. For this course, 201 persons registered. Of this number, 115 were not members of the association, but a large portion of this group subsequently joined the Association.

#### Annual Conference

It is still too early to appraise correctly the degree of success as measured by attendance which the Seventh Annual Conference and Exhibition now opening is to enjoy. Several novel innovations were tried out this year and the report of the general conference chairman, Mr. L. B. Donovan, will summarize the reaction to them. Regardless of the final attendance figures, it already is an accomplished fact that the Exhibition is larger and better than ever before and that the technical program is excellent in every respect. Those members unable to attend the conference this year will miss a great deal of value to them both in their jobs and relations with other members.

In closing, your president desires to express his appreciation for the cooperation he has received from his coworkers during his year in office. This past summer he was incapacitated for a period of nearly three months' time by a rather serious illness. During this interval Dr. N. E. Berry, vice president of the association, took over the presidential duties in addition to his other tasks. His efficient administration of association affairs during this period shows that a wise choice was made when he was elected president for the coming year.

The executive secretary, Mr. Berry Campbell, also made extra efforts to expedite the handling of association affairs during this time. Unfortunately, few of the association members realize the amount of detail that must be handled by the Central Office or appreciate the efficiency with which it is taken care of. Those who come in contact with this office daily have come to have a high regard for the manner in which it is run. Your president is confident that his successor in office will enjoy the same cooperation which he received and that the association will continue to grow and prosper as a result.

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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

### Ninth Conference Scheduled for Chicago in March '53

Chicago, Illinois, will be the site of the National Association of Corrosion Engineers meeting in 1953, it was decided Sunday, March 11, at a meeting of the association's board of directors at Hotel Statler, New York, just before the opening of the Seventh Annual Conference and Exhibition. A. B. Campbell, executive secretary, was authorized to negotiate for meeting dates during the first three weeks of the month, and if suitable dates were unavailable, to seek allocation of similar dates at Kansas City, Mo.

Plans for the 1952 Conference and Exhibition at Galveston, Texas, during March were advanced with the appointment of Walter Rodgers, long an active member of the association as general chairman.

N. E. Berry, vice president and president-elect presided at the meeting and at the earlier meeting of the executive committee the same day. President Vance N. Jenkins was suddenly stricken ill in the morning and was unable to preside.

Among principal decisions reached by the board were the following:

It was ruled that representatives of NACE on other organizations can be named only by the president of the association.

Several amendments to the organization rules prepared by E. P. Noppel,

chairman of the Policy and Planning Committee were discussed and, after considerable debate, adopted. These included amendments to the by-laws concerning the payment by National Office to sections of funds for their maintenance, and that only members of the association may be elected officers of regions and sections.

#### Anderson to Remain

H. H. Anderson, chairman of the Membership Control Committee, who previously had notified the board of his intention to resign, reconsidered and agreed to remain in his post when the board agreed to appoint someone to work with him on the problems of securing additional active memberships in the association. Mr. Anderson expressed his willingness to continue his work soliciting corporate memberships.

The consensus among the board members seemed to be that an organized effort should be made this year not only to get additional corporate members, but to secure additional active members, preferably through cooperation with local sections.

#### New Members Considered

Mr. Noppel was instructed by the board to prepare a proposal for a change in the articles of organization envisioning the addition to the board of the

chairmen of the membership control and education committees.

The board recommended the education committee be expanded to include a member in each region among whose duties would be to keep the region advised of activities of this committee in the region. The board's action came after a request of L. B. Donovan, North East Region director in which he reported region officers to have been unaware of a corrosion course being held in the region until advised of it through mailings from the institution conducting the course. Mr. Donovan said officers of the region felt considerable assistance could have been given the institution if the NACE officers had been made aware of the plans.

#### Book Prices Set

The selling prices of Technical Practices Committee 1—Control of Condensate Well Corrosion's report was set at \$8 for members and \$10 for non-members.

The Bibliographic Survey 1946-47, copies of which will be available for sale in April, was authorized to be sold at \$7 to members and \$9 to non-members. The book also will be offered in combination with the previous abstract publication, containing 1945 abstracts, at \$9 to members and \$12 to non-members for both books.

## ANNOUNCEMENT

*Manufacturers of*

**GAMA ASBESTOS PIPE LINE FELT**

*Announce a change of corporate name — from*

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## Harris Is Exhibits Chairman for 1952

Jack Harris, salesmanager for the LP Valve Division of The Cameron Iron Works, Houston, Texas, has been named exhibits chairman for the 1952 NACE Eighth Annual Conference and Exhibition to be held at Galveston, Texas, during March.

## Major Abstract Index Changes Authorized

Major changes were authorized in the arrangement of the NACE Filing System Index at meetings of the abstract committee held during the Seventh Annual Conference at New York. The changes, while they will affect the status of abstracts published under headings provided in earlier revisions, are designed to rectify what the committee considers to be material mislocations and poor definitions.

The most important changes involve the sub-classification "Fundamentals," (in the November 1, 1950 revision designated 1.8) which was moved from 1. General to 3. Corrosion Types and Influencing Factors, where it becomes 3.8. Theory. It retains only Mechanism of Reactions (1.8.4) and Passivity (1.8.6) as its subdivisions. All other subdivisions are distributed among the parts of 3.

Major classification 3 has been redesignated "Types, Factors and Theory."

3.2.5.b. Tarnishing, has been redesignated "Films" as a more general term.

Under 5.9 Preventive Measures, Surface Treatment, the subclassification "Flame cleaning" has been added and designated 5.9.2.f.

Under 1.2, General. Importance, Safety has been added as 1.2.5.

These changes will be incorporated in a revision of the index to be issued prior to the start of the printing of abstract index cards. The committee believes no major revisions of the index should be undertaken after the card program has begun. Additions to the various classifications can be made and allowances for additions have been incorporated in the index.

Miss Marguerite Bebbington, chairman of the committee is preparing, with assistance of members, a description of the index to be sent to subscribers to the card service.

## Corrosion Problems

Correspondents of CORROSION magazine have accepted the responsibility of acting as a panel to supply answers submitted to the magazine for publication under the heading "Corrosion Problems." E. A. Tice, International Nickel Co., Inc., New York City will continue as editor.

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News Deadline:  
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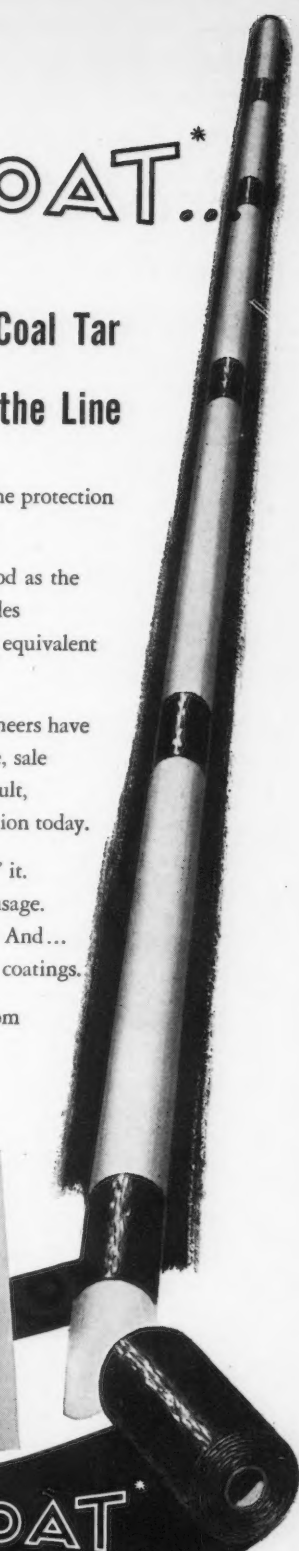
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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

### More Technical Articles to Be Sought for Corrosion

One of the principal subjects discussed at the meeting of the NACE Publication Committee held in two sessions March 12, was the urgent necessity of securing a greater supply of technical material for consideration as articles in *Corrosion*. The principal effort of the committee, in whose deliberations participated F. L. La Que, appointed chairman of the committee succeeding Dr. I. M. Parker, will be directed toward the association's technical committees who will be asked to submit papers themselves and to seek worthwhile papers elsewhere among friends in corrosion work.

Dr. F. N. Alquist, who advanced this proposal, pointed out, however, the necessity of so ordering the arrangements that the result would not affect the volume of papers available for presentation at national meetings of the association.

#### Deadlines Sought

As a means of reducing the review time, Dr. Alquist also proposed deadlines be set for review and return of technical papers at various stages of the review process. In this way, he said, it should be possible to materially reduce the long delays that have occurred frequently in the processing of papers.

Among other decisions reached were the following:

Standing as well as technical practices committees would be asked to use the first editorial page of the technical section of *Corrosion*.

It was decided to continue the practice of the past two years in compiling a tabular index of the abstracts published in *Corrosion*.

The review process for handling discussions was revised to provide that discussions be sent first to Central Office NACE, sent by Central office to authors for replies, and when discussion and reply had been returned by the author, sent to Dr. Parker, editor of *Corrosion*, unless the discussion and reply included controversial material, in which case it would be forwarded to the chairman of the editorial review committee for assignment to a reviewer.

At draft copy of a list of publications available designed to be used as a mailing piece to accompany the annual statement of membership dues will be prepared by the managing editor of *Corrosion* and submitted to the committee for further study. This is designed to make available to the member, at the time he pays his dues, a list of NACE publications from which he may select those he wants.

#### Separate Directory Considered

The committee also considered the

advisability of re-examining a decision to publish separately the annual membership directly instead of incorporating it in an issue of *Corrosion* as at present. Several decisions on this question were not resolved, but further study will be given after an estimate of the cost of an alternate method of preparing and reproducing the list is prepared.

Two possibilities were considered respecting the recurring request made of the association to furnish *Corrosion* bound by volumes. It was decided a proposal be prepared by the managing editor of *Corrosion* outlining the cost to the association of preparing a bound volume and also investigating the possibility a bindery may be found which will make an agreement respecting binding copies of the magazine when the copies are supplied by the member wanting them bound.

Further publicity on the reduced reprint charges by the association was suggested. It was recommended the tentative cost tables be published in *Corrosion* and the reductions pointed out to membership.

#### Circulation Solicitation

Soliciting subscriptions for *Corrosion* by the managing editor was tentatively (Continued on Page 26)

## What's your Corrosion Problem?

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Adequate stocks of proven corrosion prevention products are maintained at Houston.

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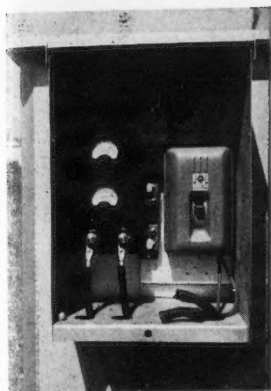
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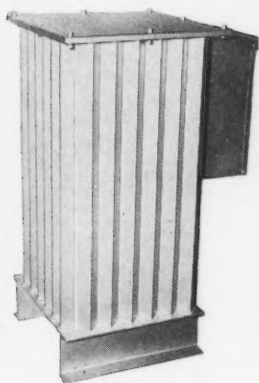
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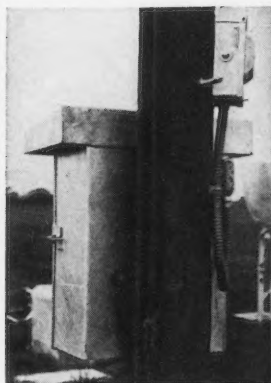
## Cathodic Protection



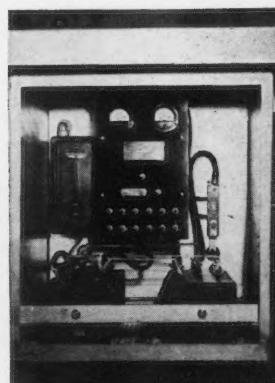
Oil-immersed, selenium rectifier—field installation showing meter and terminal box.



The NEW Westinghouse oil-immersed selenium rectifier—a 24V, 90 amp. unit just 43 inches high overall—36 gallons of oil suffice where 150 gallons were required in identical units of previous design.



Brance-Krachy air-cooled selenium rectifier in location showing pole mounting. (Method of connecting dc and ac leads optional.)



Typical unit construction—Brance-Krachy air cooled, selenium rectifier. Note sturdiness and easy accessibility.

### OIL IMMERSED RECTIFIERS

Westinghouse selenium rectifiers have long been recognized for their quality featuring:

- ★ 11 ga. plate construction, bonderized—completely weather proof.
- ★ AC circuit breaker equipped with heater type thermal overload relays.
- ★ Large meter and terminal box easily accessible for making connections and reading meters.
- ★ Unitized construction of power unit for easy removal and inspection.

### AIR-COOLED RECTIFIERS

New design features in Brance-Krachy air-cooled, selenium rectifiers are scaled to meet the demand for compactness and ruggedness in construction in this type of unit. These rectifiers are unsurpassed in quality, yet economical in terms of initial investment and years of trouble free performance. They feature:

- ★ 11 ga. plate construction—bonderized, or hot-dip galvanized after fabrication—case completely insect proof.
- ★ AC starter—heater type overload protection.
- ★ Fansteel selenium stacks—normally derated for operation at 60° ambient temperature for extra stack life.
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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

### More Technical—

(Continued from Page 24)

approved. It was provided the proposal be cleared through the Membership Control Committee as well as the Publication Committee.

Reports by the Abstract, Editorial Review and Rules Committee chairmen were heard.

In connection with the attitude of the editorial review committee toward the content of technical papers, it was recommended a broader definition of corrosion be adopted than that which confines it to metallic phenomenon. The association's point of view encompasses also, the committee decided, those materials which are principally used as substitutes for or protectors of metals.

The editorial review committee also was asked to include among the recommendations asked of the reviewer, whether or not the reviewer considered the material of the paper to be such a nature that it requires scrutiny on the score of revealing information that might be useful to a potential enemy of the United States.

Mr. E. R. Stauffacher's second draft of Guide for the Preparation and Presentation of Papers was presented. Members of the committee are to suggest further revisions, if necessary, to Mr. Stauffacher, after which a third draft will be submitted for approval to Mr. La Que.

No special price to institutions will be made for the abstract card service, it was decided, because the service if being sold at cost.

A sales campaign for the sale of 1946-47 Bibliography was outlined for early action.

Short abstracts only will be asked of authors of papers at the 1952 Conference, it was decided.

Another solicitation of libraries seeking subscribers was authorized.

The question of securing answers to Corrosion Problems was discussed and a proposal outlined to secure them.

Additional publicity on general aspects of Corrosion will be sought through co-operation with International Nickel Co., Inc.

A draft on recommended publicity procedure for association news will be prepared and submitted for consideration by the committee.

Translators who supply Corrosion with abstracts of foreign articles will be credited at the end of the abstract with the abstract so those who wish to secure copies of the translation may do so.

Copies of the official program of the New York Conference are available on request to members of the association.

Technical papers presented at the New York Conference will be reviewed by the NACE Editorial Review Committee and the editor of Corrosion, and if approved, will be published in Corrosion. No proceedings including all technical papers are published by the association.



TECHNICAL PROGRAM COMMITTEE—Norman Hackerman (standing) talks to members of the technical program committee at the 1951 Conference at New York. Technical sessions were well attended and a record number of discussions was made.

### Early Start on Abstract Cards Authorized

Miss Marguerite Bebbington, chairman of the Abstract committee reported March 12 the committee had made available the information necessary to begin printing and distributing to subscribers the NACE Abstract Filing Cards. Orders for the new service are being received at Central Office, and actual printing and distribution of the cards could begin as soon as they arrive at Houston, she said.

Several decisions relative to the abstract card service were reached during the meeting. Taking into account the possibility many subscribers to the service who elect to purchase it only in the second year of its operation probably would want copies of the cards printed during the first year, it was decided to file the plates used to print the cards during the first year's operation. If a sufficient number of subscribers wish to get the first year's cards to make it economically feasible, then it would be possible to print the number needed all at one time.

Additional adjustments were made in the filing system and in the allocation of holes to the various categories of information that the NACE system includes. It was decided also to code only the first and third letters of the author's name, instead of the first, second and third letters. This will make available these holes for other purposes.

The method of handling the section of the card allocated to the coding of the names of periodicals was discussed. A proposal by H. P. Godard was adopted calling for the allocation of a section of 99 numbers of which 50 would be assigned to the principal publications from which abstracts can be secured, a section permitting coding of 26 letters set aside and the remainder of the numbers left unused for future expansion of the list of periodicals.

#### Canvass to Be Made

A canvass of the abstracts used in the publication of the 1946-47 Biblio-

graphic Survey will be made to determine the relative frequency with which periodicals appear in the abstracts. It is presumed the principal assignment of numbers will be made to those most frequently occurring.

It was reported also that the 1946-47 Bibliographic Survey is completed and probably will be ready for sale in a few weeks.

### 1946-47 Bibliography Orders Being Taken

Bibliographic Survey of Corrosion, 1946-47, a compilation of corrosion abstracts may now be ordered for delivery from National Association of Corrosion Engineers, 919 Milam Bldg., Houston, Texas. The book consists of 288 pages 8½ x 11 inches with green cloth cover. It is designated Publication 51-1.

The following per copy prices have been set: To members, \$7; to non-members, \$9.

In combination with the 1945 volume of abstracts, Bibliographic Survey of Corrosion, 1945, the following prices have been set for both volumes: To members, \$9 and to non-members, \$12.

The 1946-47 volume contains a copy of the November 1, 1950 version of the NACE Filing System Index, a table of contents, over 2000 abstracts arranged topically with a list of cross references at the bottom of each subdivision, an alphabetical index of authors and an alphabetical subject index.

Applications for membership were taken from 22 prospective members of NACE during the Seventh Annual Conference and Exhibition at New York.

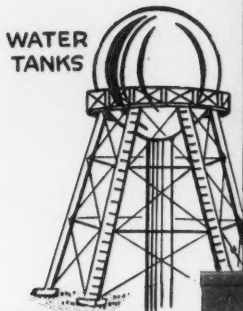
Orders were taken from 26 persons for copies of NACE publications at the association's booth during the New York Conference.



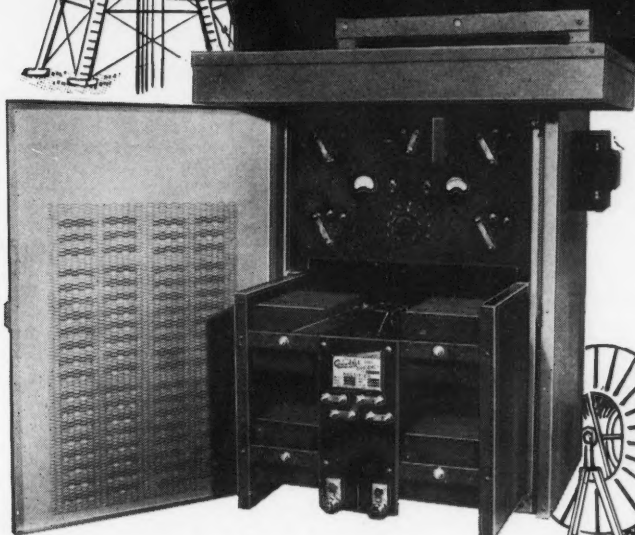
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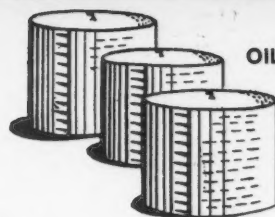
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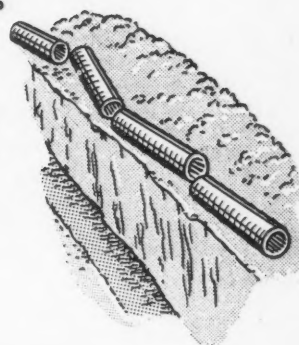


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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

# Inco Research Project Is Assigned to Yale University

## New Officers and Directors Take Over During Conference

New officers and directors, and committee members on the board of directors who took office during the annual conference are as follows:

President—N. E. Berry.

Vice-President—Mars G. Fontana.

Treasurer—R. A. Brannon.

Directors:

Representing active membership: L. A. Hugo, Phillips Petroleum Co., Bartlesville, Okla.

Representing Corporate Membership: H. A. Humble, Dow Chemical Corp., Midland, Mich. and C. P. Larrabee, United States Steel Co., Vandergrift, Pa.

Representing Regional Divisions: L. B. Donovan, Consolidated Edison Co., of N. Y., New York City; A. R. Swanson, American Telephone and Telegraph Co., Atlanta, Ga.

Ted S. Zajac, Shell Oil Co., Houston, was named chairman of the Technical Practices Committee.

F. L. LaQue, International Nickel Co., Inc., New York City, was named chairman of the Publication Committee.

Other standing committee heads were renamed.

## Projects for Future Discussed by TP-3

Many ideas for future study by TP-3 Anodes for Use With Impressed Currents were discussed at a meeting of the group during the Seventh Annual NACE Conference in New York. Paul Oliver of National Carbon Co. presided. Possible subjects of study mentioned included sizing of backfill, positioning of anodes and possible tests of impregnating materials for carbon anodes.

Late in March the four year tests of carbon, graphite and steel anodes in a variety of backfills will be completed and the final report on this phase of the group's activities will be prepared for publication and distribution.

## Substitute for Street De-Icing Salt Asked

Dr. Mars Fontana, chairman of the Technical Practices Committee was asked by the board of directors of NACE to investigate the feasibility of forming a technical committee to seek substitutes for salt used to melt street ice. L. B. Donovan, North East Region Director, stated companies in New York and Northern cities where salt used to melt ice on streets, were suffering severe and accelerated damage to their underground plant as a result of the salt. Heavy losses in equipment of all kinds was being experienced, Mr. Donovan said.

The discussion on this proposal also revolved around the heavy damage to automobile bodies and other vehicles from this same corrosive, the opinion being expressed public education of the losses being suffered, and finding an appropriate substitute probably would be necessary to bring about change in practices.

## Condensate Well Report Published, Now Ready

The Report of Technical Practices Committee No. 1 on the Field Testing of 32 Alloys in the Flow Streams of Seven Condensate Wells has been published and is available for delivery on order from Central Office, National Association of Corrosion Engineers, 919 Milam Bldg., Houston 2, Texas. The report, which is designated Publication 50-3, measures approximately 8½ x 11 inches, is bound with green paper covers and comprises 168 pages.

The book is organized into four sections: Organization and History, Preliminary Studies, Testing of Specimens and Discussion of Data. Numerous tables and graphs detailing the results of measurements and tests are included.

The per copy price is: For association members, \$8, and for non-members, \$10.

A Fellowship in the Metallurgical Department of Yale University under direction of Dr. W. D. Robertson will be established with the \$5000 grant made available by The International Nickel Co., Inc. for research on sulfide corrosion cracking, with emphasis on the fundamental mechanisms involved.

Technical Practices Committee 1-G Chairman R. S. Treseder advised the NACE Board of Directors during the New York Conference, the grant would cover one year's work, that active work would start about July 1 but that committee members would meet Dr. Robertson for planning in May or June.

## Zajac Named Chairman Of NACE TP Committee

Ted S. Zajac, Shell Oil Corp., Houston, past-chairman of TP-1, has been appointed chairman of the Technical Practices Committee by the association's board of directors. He succeeds Mars G. Fontana, elected vice-president.

At a general meeting of sub-committee chairmen, who constitute the parent group, the advisability of each subcommittee adding a vice-chairman was discussed. Some reported this had proved helpful and it was recommended provision be made for adding a vice-chairman for each sub-committee.

The usefulness of the TP Committee Directory was praised and it was recommended copies be sent to each member of the committee and sub-committees.

## Activities Scope Is Defined for TP-6K

The scope of the activities of TP-6K on Chemical Resistant Masonry Construction was more clearly defined at a meeting of 10 members and guests at Hotel Statler, New York City during the Seventh Annual NACE Conference. Robert R. Pierce, Pennsylvania Salt Manufacturing Co., Philadelphia, Pa., chairman, presided.

The scope and activities defined were: Supporting Structures.

Impervious Inner Linings—lead, bitumens, natural rubber, synthetics and hydraulic cements.

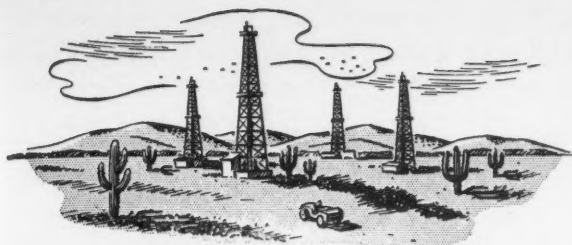
Masonry Materials—brick, cements, ceramics and carbon shapes.

Physical data to be sought on the materials includes temperature limitations, density, bond strength, thermal conductivity, compressive strength, dielectric strength, coefficient of expansion and others depending on the application and process.

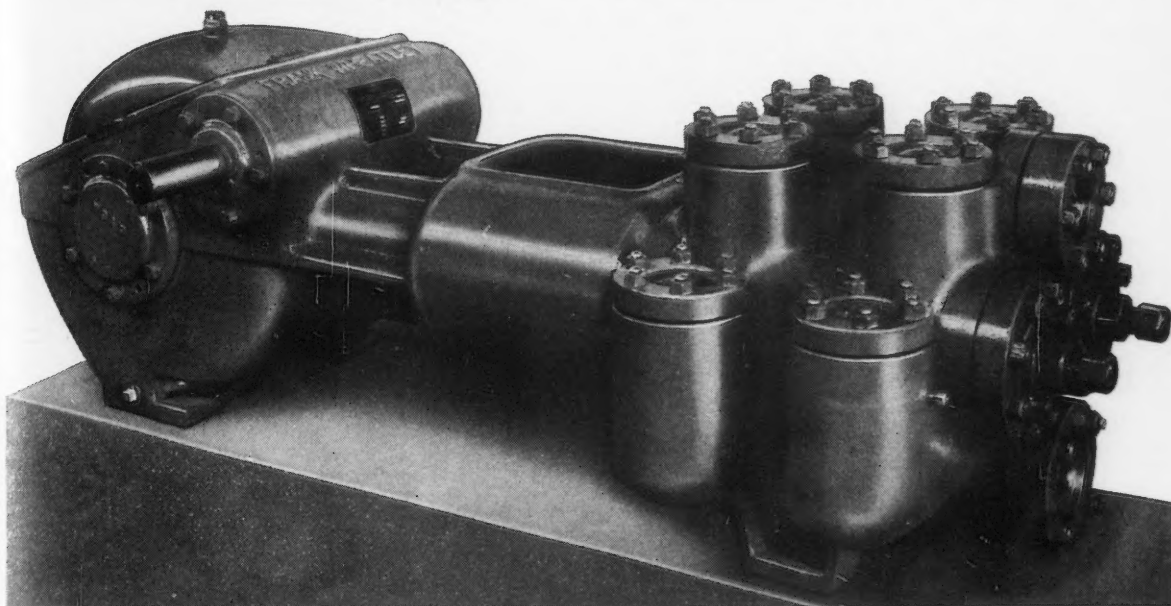
Chemical resistant properties will be considered in cooperation with TP-5 Corrosion Problems Involved in the Processing and Handling of Chemicals.



TECHNICAL PRACTICES COMMITTEE 2—Galvanic Anodes for Cathodic Protection, met at Hotel Statler, New York City, during the Seventh Annual Conference.



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Because of unusually heavy industrial and defense demand, rationing of nickel has been in force since July 1st. On January 1, 1951, National Production Authority Order M-14, respecting the consumption of primary nickel, went into effect.

We shall continue to issue information on new developments and user experience with nickel-containing materials as we believe that dissemination of technical data and service experience can help to promote the intelligent utilization of critical materials, so essential in these times.

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## REPORT ON SEVENTH ANNUAL CONFERENCE AND EXHIBITION

### TP-1 Committee Holds Daylong Meeting; Harry E. Waldrip Is Elected Chairman

Harry E. Waldrip, Gulf Oil Corp., Houston, newly-elected chairman of TP-1 Corrosion of Oil and Gas Well Equipment presided at an all-day meeting of the committee at Hotel Statler, New York City March 11. The 1950 activities of the group were discussed by 31 members and guests.

Ernest Kartinen, Signal Oil and Gas Co., (Pacific Coast) reported one of the principal activities of his group was evaluation of applied means of controlling oil and gas well corrosion in California fields. A report to the main committee on the efficacy of many "gadgets" is expected to be issued by his committee within the year, he said.

TP-1B Condensate Well Corrosion. R. C. Buchan, Humble Oil and Refining Co., Houston, presented a report on the use of alloy steels, nickel-plated steels, baked-on plastic coated tubing and the effective use of several types of inhibitors in the control of condensate well corrosion. Discussion emphasized further studies of the use of plastic coatings were needed because of likely shortages of alloying materials for corrosion resistant steels. Special consideration should be given to evaluating the lasting effect of inhibitors also, it was felt.

TP-1C Sweet Oil Well Corrosion. H. L. Bilhartz, Atlantic Refining Co. chairman, and newly named vice-chairman of TP-1, summarized data contained in a survey of 359 wells reported January 25, 1951. Factors studied and recorded were: Type, i.e. tubing or surface; age of wells, oil production, water production, paraffin problems, emulsion problems, sand production, bottom hole pressure, bottom hole temperature, surface tubing pressure, gas-oil ratio and depth.

TP-1D Sour Oil Well Corrosion. J. A. Caldwell, Humble Oil and Refining Co. and Randell L. Elkins, Shell Oil Co., recently named co-chairman will initiate further studies of sour oil well corrosion. Recall of former chairman H. D. Murray into the armed service has handicapped this committee.

TP-1E Bi-Metallic Galvanic Corrosion in Oil and Gas Wells. Chairman Walter F. Rogers in his last report of this sub-committee said very few cases of galvanic corrosion had been observed

in oil well equipment. Mr. Rogers recommended the sub-committee be discharged.

Acting on this recommendation, the main committee discharged TP-1E and added to the scope of TP-1F Metallurgy, making the title "Metallurgy and Galvanic Corrosion." The scope of the sub-committee was broadened to in-

clude galvanic corrosion in tubing strings of heterogeneous metals. Fred Prange, Phillips Petroleum Co. was named co-chairman with V. V. Kendall, National Tube Co. to further the project.

TP-1G Sulfide Stress Corrosion. Currently the outstanding project of this group is administration of the grant made available by International Nickel Co. Inc. for applied research in and educational institution under the committee's direction. Chairman R. S. Treseder, Shell Development Co. reported action imminent on the research grant.



TECHNICAL PRACTICES COMMITTEE 16—Electrolysis and Corrosion of Cable Sheaths, shown here during a meeting held at Hotel Statler, New York City, during the Seventh Annual Conference and Exhibition of NACE. Irwin C. Dietze, chairman, is seated fourth from the left, front row.



TECHNICAL PRACTICES COMMITTEE 5—Corrosion Problems Involved in Processing and Handling Chemicals are shown at Hotel Statler, New York, where the group met during the annual conference.

### Galvanizers Committee

The Galvanizers Committee, which is sponsored by the American Zinc Institute, will hold its twenty-fifth meeting at St. Louis, Mo., May 21-22. W. L. Diehl, assistant superintendent of galvanizing at the Steubenville, Ohio, plant of Wheeling Steel Corp., heads the program committee.

TECHNICAL PRACTICES COMMITTEE 3—Anodes for Use With Impressed Currents met at Hotel Statler, New York City, during the Seventh Annual Conference and Exhibition.





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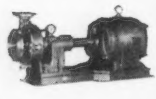




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## Exhibitors Ask For Liberalized Policy On Free Admissions

More liberal arrangements for representatives of exhibiting companies at National Association of Corrosion Engineers' annual conferences was requested at a meeting of exhibitors' representatives at Hotel Statler, New York City, on the final day of the Seventh Annual Conference and Exhibition. It was suggested staff members be permitted to enter the exhibit area without registering if they are to be present one day only. Exhibitors also suggested the association reexamine its policy regarding giving free access to exhibits of guests of exhibitors.

Generally, exhibitors' comments were favorable, and liberal praise was given L. B. Donovan, general chairman of the 1951 meeting and members of his committees and to G. E. Seidel, exhibits chairman and his committee.

Other points discussed at the meeting included:

Make arrangements so exhibitors can start setting up booths earlier.

Investigate possible methods of fairer distribution of preferred booth positions.

Are lotteries or giving away prizes objectionable?

Should the schedule of technical papers be changed to better accommodate exhibitors?

Guides should be provided at 1952 conference to take people to booths they are seeking.

Continue to close exhibit at set time and allow no premature dismantling.

## Schmidt Is Elected Vice-Chairman of TP Committee 5C

H. W. Schmidt, Dow Chemical Company, Midland, Mich., chairman of TP-5C Sub-Surface Corrosion by Alkaline Solutions, a subdivision of TP-5 Corrosion Problems Involved in Processing and Handling Chemicals, was elected vice-chairman of the latter group at a meeting at Hotel Statler, New York City during the Seventh Annual NACE Conference. Chairman Mars G. Fontana, Ohio State University, presided. Sixteen members and guests were present.

The committee sponsored the Chemical Industry Symposium at the New York Conference and presented three of the papers in it. Two sub-committees already are planning papers for the 1952 Conference at Galveston and it appears likely TP-5 will sponsor the Chemical Industry Symposium again.

The committee heard a proposal from TP-6K regarding cooperation in studies contemplated and the future work of TP-5B Design of Equipment for Corrosive Services was discussed.

Advance notices of meetings of organizations other than NACE engaged in corrosion work will be published on request in the "Meetings" column.





# Corrosion Abstracts

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(Complete Topical Index used for Corrosion Abstracts may be found in FIVE YEAR INDEX TO TECHNICAL ARTICLES, Corrosion, December, 1950.)

### \* PAGINATION OF CORROSION ABSTRACTS

Two numbers appear on each page of Corrosion Abstracts. The number in the upper outer corner is for page sequence within the issue only. The number in the lower outer corner, which is followed by the letter "a," denoting "abstracts," is for the convenience of those who bind Corrosion Abstracts by volumes. Because both numbers appear on each page and because it is believed indexing by the volume serial number will be more useful, the "Index to Corrosion Abstracts" is keyed to the number in the lower outer corner of each page followed by the letter "a."

## GENERAL

### • Fundamentals

1.8, 4.3, 6.2

Oxide Films Formed on Pure Iron in Concentrated Hydrochloric Acid. W. I. Whitton (University of Melbourne. *Nature*, 163, 763-764 (1949) May.

The corrosion rate of enameling iron is fairly constant and reproducible when the test specimens have been precleaned in hot dilute hydrochloric acid, but is one-third lower after treatment in cold concentrated hydrochloric acid. This sudden decrease in corrosion rate in 5-7 N hydrochloric acid may be due to the formation of an oxide film. Electron diffraction results showed that samples treated in the hot dilute acid had an almost pure iron surface but that specimens treated in the concentrated cold acid had a film of either  $\text{Fe}_2\text{O}_3$  or  $\gamma\text{-Fe}_2\text{O}_3$ ,

whose diffraction patterns are indistinguishable. Freshly polished, untreated specimens showed patterns of iron and of  $\text{Fe}_2\text{O}_3$ ,  $\text{H}_2\text{O}$  and  $\text{Fe}_2\text{O}_3$  or  $\gamma\text{-Fe}_2\text{O}_3$ .

A possible explanation of oxide formation may be furnished by Muller's theory of passivity. The anodic process may change its nature at high current densities. As a consequence, ferric instead of ferrous ions would be emitted, hydroxyl ions would be deposited and oxidation would occur. In more concentrated solutions, the current density resulting from local cell formation should be greater than in dilute solutions. The observed fact that mild steels and spring steel do not become passivated in cold concentrated hydrochloric acid may be due to the stirring effect of the rapidly evolved hydrogen gas.

The enameling iron investigated contained 0.01% carbon, 0.1% nickel, 0.1% chromium, 0.005% silicon, 0.14% manganese and traces of copper, tin, arsenic, aluminum and calcium. Corrosion rates were measured with a special apparatus by following the oxygen consumption.—PDA.

## TESTING

### • General

2.1, 2.7

The Choice and Interpretation of Corrosion Tests. G. T. Colegate. *Sheet Metals Inds.*, 27, No. 275, 259-266 (1950) Mar. Considers the factors involved in choosing tests which will give reasonably reliable information that can be used in practice to predict the probable life or performance of a metal under service conditions. A number of the

commoner types of corrosion tests are considered and the value of the different tests are discussed in terms of practical performance. Discussion includes accelerated tests, designing a corrosion test, choice of criteria for assessing corrosion, total-immersion, alternate-immersion, atmospheric-exposure and salt-spray tests, galvanic corrosion testing, anodic testing, loss-in-weight measurements, tests on metallic coating and special tests.—INCO.

### • Laboratory Methods and Tests

2.3, 4.3, 6.2

Corrosion of Wet Steel by Hydrogen Sulfide-Air Mixtures. D. C. Bond and G. A. Marsh. *Corrosion* (Technical Section), 6, 22-26; discussion 26-28 (1950) Jan.

Describes experimental apparatus and procedure and presents and summarizes results.—BLR.

2.3, 3.3, 6.6

Practical Evaluation of Wood Preservatives. W. A. Edwards. *Paint Tech.*, 14, No. 164, 351-3 (1949).

The simple test of partly burying specimens of wood containing preservatives is unsatisfactory. A method is described whereby the wood specimens are placed in contact with a prep. mycelium growing on the surface of an agar/malt extract medium. Quantitative results are obtained by exposing a series of panels containing varying concns. of preservative. The lowest concn. which inhibits fungal attack is thereby determined.—RPI.

## PRIMARY SOURCES OF ABSTRACTS PUBLISHED IN CORROSION

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.  
ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.  
AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 500 5th Ave., New York 18, N. Y.  
BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.  
BLR—Battelle Library Review, Battelle Memorial Institute Library, 505 King Ave., Columbus, Ohio.  
BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.  
CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.  
CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.  
CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.  
EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.  
GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.  
INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.  
IP—Institute of Petroleum, 26 Portland Place, London W.1, England.  
MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

ME—Marine Engineering, The Institute of Marine Engineers, 85/88 The Minories, London E. C. 3, England.  
MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.  
NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 18, Illinois.  
NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.  
PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.  
RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.  
RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.  
RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.  
TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.  
TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.  
UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.  
ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

## 2.3, 2.7

**Reproducibility of Humidity Exposure Tests.** Lewis E. Michael, U. S. Air Materiel Command, U. S. Air Materiel Command, Aid Technical Index No. 21672; U. S. Department of the Air Force, Technical Report No. 5690 (1948) April.

Fifteen groups of steel panels, each group prepared with a different surface finish, were exposed in an AN-H-31 humidity cabinet under identical experimental conditions. Corrosion data were assembled from ten panels of each group exposed bare and from ten like panels dip-coated with a rust-inhibited aircraft oil.

In general, the coarser types of surface finish gave a more protective combination with, and retained more of the oil. They also showed a better statistical distribution of failures, although the latter did not generally follow a normal distribution regardless of the scoring method used.

A comparison of the fifteen surface types after 1.5-hr exposure in the humidity cabinet showed that the bare surfaces most susceptible to corrosion were the shot-peened, sand-blasted, pickled, electropolished, and lead-tin lapped. A lighter colored rust coat entirely covered the panels prepared by loose abrasive lapping, hydrolapping, and hand abrading with dry paper. No direct correlation between the activity of these surfaces and their performance at high humidity after coating with oil was observed.

The four surfaces that seem most likely to provide reproducible results in these tests are the shot blasted, sand blasted, pickled, and loose abrasive

lapped surfaces. None of the results are necessarily indicative of the service performance of the rust preventive.

The steel used was SAE 1045 cold-rolled strip steel with a natural mill or rolled edge, a No. 1 temper (hard) and a No. 2 finish. It contained about 0.5% carbon, 0.7% manganese, 0.3% copper, 0.15% silicon, 0.01% phosphorus, 0.03% sulphur, 0.02% aluminum, 0.02% chromium, and 0.07% nickel. The surface finishing methods used included shot peening and sand blasting, both with a Pangborn machine; pickling for 10 min. in inhibited sulfuric acid at 160 F; superfinishing; cold-rolled mill finishing; electropolishing in sulfuric-phosphoric acid at 300 amp. per sq. ft.; loose abrasive lapping; hand abrading, both dry and under kerosene; surface grinding on a Thomson Surface Grinder; hydro-lapping; grit polishing and lead-tin lapping. The oil used for dip-coating was a mixture of 30% AN-O-6a rust-inhibited aircraft oil and 70% uninhibited oil of the same base stock. Repeat tests were performed on five surface finishes with 100% rust-inhibited oil.—PDA.

## 2.3, 5.3

**Note on an Examination of the Bendix Method for Determining Coating Thickness on Tinplate.** F. W. Salt. British Iron and Steel Research Assn., Laboratories, Swansea, Wales. British Iron and Steel Research Assn., London, Paper MW/C/48/48. *J. Iron Steel Inst.* (London), 161, 118 (1949) Feb.

The method developed by Bendix, Stammer and Carle to determine the weight of tin coatings is considered reasonably accurate provided the time of treatment is not unduly prolonged beyond that required to strip the coating.

This method consists in removing the tin by anodically polarizing, in hydrochloric acid containing iodine, a tin-plate disc suspended by its edge from an electromagnet. Porous pots on either side of the disc enclose carbon-rod cathodes. The iodine is reduced by the tin entering the solution, and the weight of tin removed is calculated from the decrease in the iodine content of the anolyte.

When electrolysis is continued after the tin is removed, the apparent coating weight becomes progressively greater. It is considered unlikely, as suggested, that this is due to reduction of iodine by ferrous iron dissolved from the specimen. It may rather be ascribed to a direct combination of iodine and metallic iron at the anode formed by the specimen, facilitated by migration of  $I_2^-$  ions to the anode. Another source of error not mentioned by the originators of the method is loss of iodine by volatilization, unless the anolyte is placed in a stoppered conical flask. When this was done there was no loss of iodine within 5 min. at 0 C, and only 0.0004 g. at 25 C.

An indication of the time at which stripping is complete could not be obtained as there were no well-defined steps in the anode potential/time graphs of several tinplate specimens examined. An approximation can be obtained from theoretical calculations based upon the observation that 16- to 17-oz. coatings could be stripped completely in 1 min. at a current density of 0.375 amp. per sq. in. with an error not greater than 2% resulting from the loss of iodine by volatilization and reaction with iron. The actual time required for stripping may be somewhat longer than calculated because of the uneven thickness of the

coating and the nonuniform density of the applied current. These factors may expose the base metal before all the tin is removed and current may be used to dissolve iron.

The pole piece of the electromagnet used for suspending the specimens should be as small as possible; otherwise the anodic current density on the area of the sample adjacent to the pole piece is lower than elsewhere and some tin remains after the rest of the sample is stripped.—PDA.

## 2.3

**Examination of Surfaces.** J. W. Sawyer. *J. Amer. Soc. Naval Eng., Inc.*, 61, No. 4; 819-827 (1949) Nov.

Permanent and accurate three-dimensional records of surface finish and damage can now be made. The process is simple and can be used by inexperienced personnel without weighing or heating equipment. The record is made by casting onto the surface under study a thermosetting resin which hardens in approximately 20 min. after the addition of a catalyst. The resin and catalyst are preweighed and packaged in small containers ready for immediate use. External heat and pressure are not required. After the resin hardens the casting is removed for study. The negative replica may be tested with a profilometer or similar surface-measuring instrument without damage to the casting. This method of recording surface conditions is considered an invaluable tool for research, test, development, manufacturing and inspection facilities.—TDD.

## 2.3, 6.2

**Corrosion of Molybdenum-Bearing Stainless Steel Weld Metals.** A. L. Schaeffler & R. D. Thomas, Jr., Arcos Corp. Paper before AWS, Ann. Mtg., Cleveland, Oct. 17, 1949. *Welding J.*, 29, No. 1, 13s-24s; discussion 24s-31s (1950) Jan.

Eleven compositions of weld metal within range of analysis of Types 316, 317, 318 and extra low carbon 316 were subjected to boiling 65%  $HNO_3$  and to boiling Cu sulfate  $H_2SO_4$ . Each composition was tested in the as-welded state and in four conditions of heat treatment. The compositions were adjusted by varying the Cr and Ni contents in such a manner as to produce microstructures with ferrite varying from 0-8%. In boiling  $HNO_3$ , the corrosion rates were consistently good only after a quench-annealing heat treatment. Intergranular carbide precipitation in Types 316 and 317 accounts for the high rates observed in some specimens treated at 1200-1300° F. Since Type 318 and 0.03 C Type 316 also showed high rates, the presence of an intergranular sigma precipitate is postulated. The duplex structures containing 6% or more ferrite are resistant to intergranular attack. At 1550° F carbides and sigma become agglomerated and the  $HNO_3$  rates are substantially improved. During heat treatments at 1300 and 1500° F any ferrite which may be present transforms to sigma which leaves the ductility of the weld metal but this type of sigma is relatively attacked by  $HNO_3$ . In the as-welded condition the results vary considerably depending upon the type and location of the carbide and sigma precipitates. In 500 hr. tests in boiling Cu sulfate- $H_2SO_4$ , corrosion is evident only in those specimens containing intergranular carbide.  $HNO_3$  tests of welded joints revealed no additional information that is not found in the speci-

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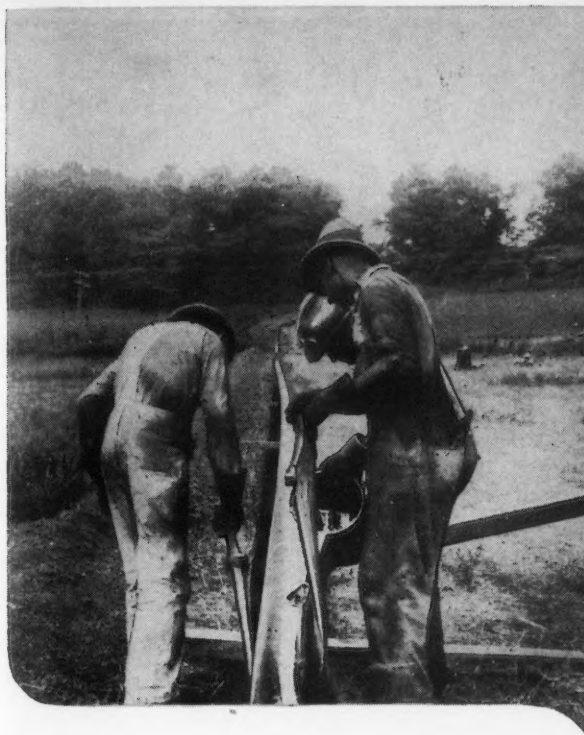
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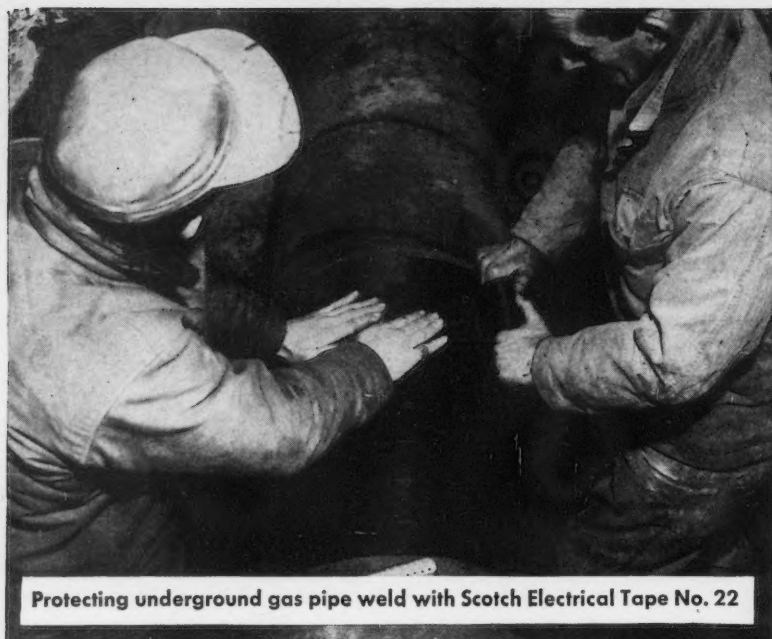


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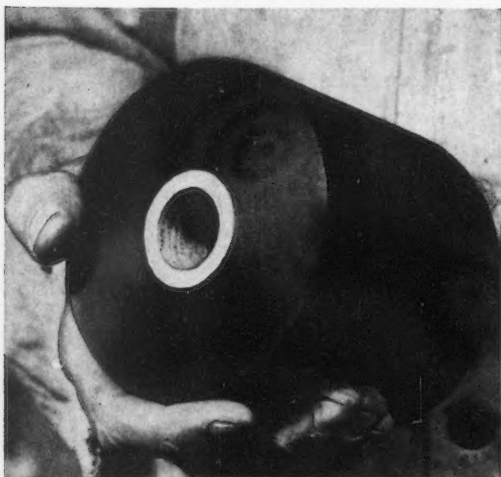


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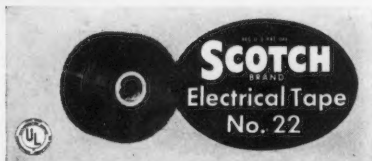
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mens obtained from all-weld-metal pads. The interpretation of corrosion data from joint specimens is largely qualitative. Comments by V. N. Krivobok are included in the discussion.—INCO.

### 2.3, 4.4

**Heating Metal Specimens in Corrosion Tests.** R. F. Thirsk, G. H. Botham and G. A. Dummett. *Nature*, **164**, 1015 (1949) Dec. 10.

In determining resistance of metals to boiling organic liquids, various methods of heating were tested. Greater solution rates and better reproducibility of results were obtained by induction heating.—BLR.

### 2.3, 5.4, 4.6

**Electrochemical Studies of Protective Coatings on Metals—Pt. II—Resistance and Capacitance Measurements on Painted Steel Immersed in Sea Water.** F. Wormwell and D. M. Brasher. *J. Iron & Steel Inst.*, **164**, Pt. 2, 141-148 (1950) Feb.

Alternating-current measurements of electrical resistance and capacitance were used to investigate the behavior of painted steel immersed in sea water. The changes in these electrical properties have shown good correlation, throughout the whole period of breakdown of the paint, with the incidence and progress of corrosion of the underlying metal. The technique was used to investigate the influence of the type of paint, of adverse conditions during painting, and of aeration and stirring of the sea water.—INCO.

### 2.3, 5.4, 2.7

**Laboratory Accelerated Weathering Tests of Asphalts or a Bituminous Mixture.** J. Zapata. *Proc. Assoc. Asphalt Paving Technol.* **16**, 154-73 (1948). *Chem. Abs.*, **43**, No. 19, 7675 (1949).

The author discusses various factors, such as the proper use of the source of radiation, the prepn. of test films, the selection of the cycle of exposure and the detn. of failure, and the identification of the changes, phys. and chem., which occur in the film. Evaluation of accelerated weathering tests is done in the author's lab. by means of a spark test, followed by a stain test.—RPI.

## • Instrumentation

### 2.4

**New Coating-Thickness Gage.** *Can. Chem. & Process Ind.*, **34**, No. 2, 158 (1950) Feb.

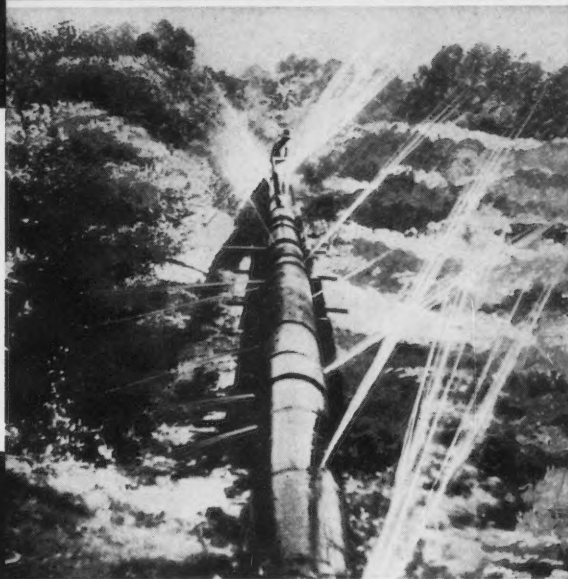
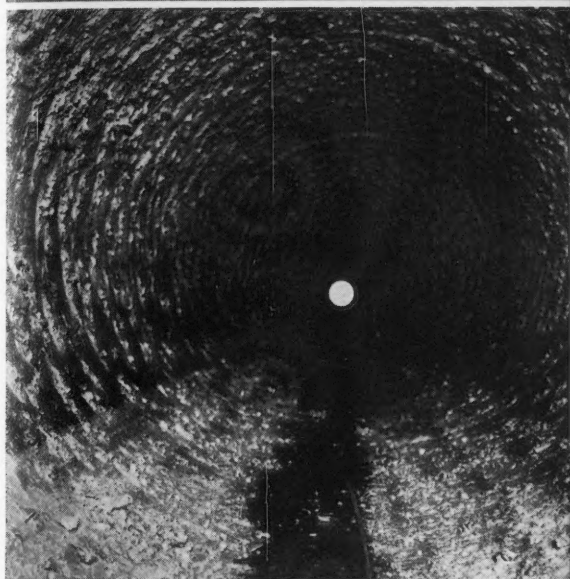
A new special-purpose Magne-gage for measuring the thickness of Ni coatings on iron or steel in the range of 0.001-0.0045 inch, by magnetic means, without injuring the coating or base metal, is announced by the American Instrument Co., Inc.—INCO.

### 2.4, 3.5

**An Apparatus for Testing the Corrosion-Resistance (of Metals) Under Variable Bending Stresses.** H. J. Seemann. *Metallüberfläche*, (A), **3**, No. 4, 85-86 (1949).

A simple apparatus is described and illustrated, for carrying out stress-corrosion tests. One end of the specimen is fixed, by means of two screws, to the top of the upright arm of an L-shaped holder. The other end of the specimen has a hole drilled in it, through which

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passes a bolt attached to the extremity of the base of the L. The load is applied to the specimen by screwing down a nut which has a knife-edge bearing surface. The magnitude of the load can be easily determined and can be varied by altering the position of the nut. The shape and dimensions of the specimen are so designed that there is a constant stress over the area of the working surface of the specimen.—MA.

- 2.4 **Radiography—A Refinery Corrosion Inspection Tool.** J. H. Stewart, Industrial Radiography Lab. *Petro. Proc.* 4, No. 11, 1211-1214 (1949) Nov.

Radiographic inspection is being used by some Gulf Coast refiners for determining corrosion, wall thickness and other conditions of vessels, piping and so on. Its advantages are that, in many instances, equipment to be studied need not be shut down, and that a source of electric current is not necessary. The technique required is such that in most cases outside service organizations are used.—INCO.

- 2.4 **Detection of Defects in Metals by Super-sonic Waves.** Manuel Torrado Varela and Manuel M. Alvaro Periane. *Tecn. Metallurgica*, 5, No. 42, 257-265 (1949).

An account of the applications of English ultrasonic apparatus in detecting faults in metallic materials.—MA.

- 2.4 **Humidity Testing Cabinet and Improved Humidity Regulator.** J. R. Van Wazer. *Anal. Chem.*, 21, No. 10, 1242-3 (1949).

Close humidity regulation was achieved by letting steam into a cabinet through a solenoid valve controlled by a humidity-sensitive resistor. A description and wiring diagram for a sensitive relay activated by resistance variations are given.—RPI.

- 2.4 **An Apparatus for Detecting Superficial Cracks in Wires.** P. Zijlstra. *Philips Technical Review*, 11, 12-15 (1949) July. Describes use of high-frequency ac in the above.—BLR.

## CORROSION TYPES & INFLUENCING FACTORS

### • Types

- 3.2, 5.3 **Hydrogen Embrittlement.** C. L. Faust. *Plating (USA)*, 35, No. 10, 1043 (1949) Oct.

An answer to a query about the time that may elapse between the zinc plating of thin spring steel and the heat treatment to remove hydrogen embrittlement. The inquirer's opinion, that a delay of up to three days is harmless, is confirmed. Though there is a tendency for hydrogen to be released slowly at room temperature, heat treatment is necessary to effect full recovery.—ZDA.

### • Factors Biological

- 3.3 **Mechanism of Action of Copper 8-Quinolinate.** R. E. Vicklun and M.

Manowitz, Ft. Belvoir. *Tech. Data Dig.*, 15, No. 5, 18-21 (1950) May 1.

A theory of the mechanism of fungistatic action of copper 8-quinolinate is proposed. This textile preservative has been found to be outstanding for inhibiting the mildewing and rotting of various materials. Molecules of copper 8-quinolinate dissociate to form 8-hydroxyquinoline and copper ions, each of which performs different but related functions. The 8-hydroxyquinoline inhibits the growth of fungi by precipitating metals which are essential for their growth. Fungi are capable of destroying the activity of 8-hydroxyquinoline, probably by oxidation. The copper ions interfere with the metabolic process or product which destroys the 8-hydroxyquinoline; thus, both the copper ions and 8-hydroxyquinoline are required to achieve maximum fungistatic activity. The theory also implies two other approaches to the synthesis of new fungicides, namely, the use of other chelating agents and finding a substitute for the copper ion.—TDD.

- 3.3, 6.6 **Impregnation of Shipbuilding Timber.** H. Wagner. *Hansa*, 86, 672 (1949) July 9. *J. Brit. Shipbuilding R. A.*, 4, No. 9, 433 (1949).

Different methods of impregnation of shipbuilding timber with salt solns, as a protection against fouling are discussed. The timber is either fully impregnated before assembly or the parts already assembled are drilled and the holes then filled with conc. salt soln. and stopped with wooden plugs.—RPI.

- 3.3, 6.6 **Treatment of Vinyl-coated Cotton Fabric for Resistance to Fungus Growth.** C. A. Willis. U. S. Air Materiel Command Memo. Rept., 1948, Serial No. MCREXM-M5339, Add. IX, 6 pp. *Prev. Det. Abs.*, 7, T 28 (1949).

1-50% of Cu 8-quinolinate incorporated in the coating protects both coating and base cloth.—RPI.

### • Factors Chemical

- 3.4, 4.3, 4.6, 5.8 **Action of Mineral Salts on Metals.** A. H. Warth. *The Crown*, 38, No. 5, 13 (1949). *Chem. Abs.*, 43, 6962 (1949).

Water from usual municipal sources may be relatively non-corrosive to metals, but chemicals employed to treat the water for beverage or industrial uses may make it corrosive. Tests were made on three kinds of tinned metal, three types of stainless steel, and six types of Ni-Cu alloy. Corrodents were solutions of individual mineral salts in water free from other minerals, at a concentration of 500 ppm.  $\text{CaCl}_2$  was found to be the most corrosive of those used, followed, in decreasing order, by  $\text{NaCl}$ ,  $\text{CaSO}_4$ , and  $\text{Ca}(\text{HCO}_3)_2$ .  $\text{NaHCO}_3$  had very little effect on most of the metals used. Corrosion of pasteurizers can be inhibited by addition of one lb. of borax to 100 gal. of the average chlorinated water.—INCO.

- 3.4, 6.4, 4.3 **Surface Reaction Between Aluminum and Mercuric Chloride.** (In Italian.) G. Bolognesi. *Alluminio*, 18, 493-497 (1949) Sept.-Oct.

The attack on Al of various degrees

of purity by  $\text{HgCl}_2$  was investigated by electrochemical means. The influence of Hg and HCl concentration on the process was established. Data are charted. 16 ref.—BLR.

### • Factors Physical & Mechanical

- 3.5, 4.3 **Stress Corrosion Cracking of Mild Steel.** D. Cubicciotti and W. Boyer. *Welding J.*, 29, No. 3, 140s-145s (1950) Mar.

A study of the stress corrosion cracking of mild steel wires was made. Charts of the time required for breaking yield points, and grain size after various heat treatments are given. The effect of concentrations of corroding nitrate solutions and their temperatures was also studied. It was found that stress alone does not render the wire more susceptible to cracking, but exposure to corroding solutions alone does decrease breaking time but only by 30 minutes for a 120 min. exposure. 10 references.—INCO.

- 3.5, 7.3, 4.6 **Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves at Marysville, Second Test Program.** J. M. Decker, H. A. Wagner and J. C. Marsh, Detroit Edison Co. Paper before ASME, Ann. Mtg., New York, Nov. 29-Dec. 3, 1948; Paper No. 48-A-118. *Trans. ASME*, 72, No. 1, 19-24; Disc., 24-26 (1950) Jan.

Materials tested includes Navy M bronze, 5 Cr-0.5 Mo, 12 Cr, 18 Cr-8 Ni, Cr-Ni-Mo, and C steels, leaded bronze, 1.25 Cr-0.5 Mo steels, and Cr plating. Corrosion-erosion tests at 320 and 385° F indicated that at these temperatures, C steel is attacked to a lesser extent than at 250° F, whereas the reverse is true of the Cr-bearing steel. However, the rate of attack of the Cr steels is still only a fraction of that of C steels, so that use of the alloy steels for boiler-feed-pump-parts is warranted at the higher temperatures also. Increasing the pH of the feed-water from 7.6 to 8.4 doubled the corrosion-erosion attack on C steel in the Marysville boiler feed-water at 250° F, as compared with previous tests at lower pH. Of two bronzes tested, Navy M material appeared satisfactory at temperatures up to 320° F. A leaded bronze was unsatisfactory at all test temperatures in this program.—INCO.

- 3.5, 6.4 **Prevention of Stress Corrosion Cracking Service.** E. H. Dix, Jr. *Metal Prog.*, 56, No. 6, 803-806 (1949) Dec.

The development and successful commercial production of the aluminum-zinc-magnesium alloys is discussed. The early alloys of the Al-Zn-Mg type were very susceptible to stress corrosion cracking, which prevented their use. Since their early development, great emphasis has been placed on improving the resistance to stress corrosion cracking of these alloys, in the efforts to produce structurally useful alloys of this type. Stress corrosion cracking is caused by the combined effects of a high enduring tensile stress at the surface and corrosive attack. Corrosion attack initiates small fissures which cause a stress concentration at their base, which in turn, causes the fissures to open further, thus exposing fresh metal to corrosive attack. Failure



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occurs by these mutually accelerating effects. While it is comparatively easy to determine if a product is susceptible to stress corrosion cracking, it is far more difficult to determine if it possesses a degree of susceptibility which will hamper its general usefulness. To answer this question new alloys must be compared with an established alloy which has shown good service. In testing new alloys high residual tensile stresses are induced by three general conditions: 1) assembly methods, 2) fabrication procedures and 3) quenching. These tests and their results are described in detail and the author concludes that even with products which exhibit some degree of susceptibility to stress corrosion cracking under service conditions in the presence of a high enduring tensile stress, satisfactory performance can be obtained by merely avoiding the unnecessary high surface tensile stresses.—ALL.

### 3.5 Investigation of Fretting Corrosion by Microscopic Observation. D. Godfrey, Lewis Flight Propulsion Lab. NACA, Tech. Note 2039, 31 pp. (1950) Feb.

An experimental investigation using microscopic observation of the action was conducted to determine the cause of fretting corrosion. In the metal-against-metal group, mild Cr, and stainless steels, Cu, and Al were vibrated against mild steel. In the metal-against-non-metal group, the 5 metals plus Pt were each vibrated against glass microscope slides, mica, and Lucite and extensive observations were made with  $\frac{1}{2}$ -inch-diameter Cr-alloy steel balls and the glass slides. Convex surfaces were vibrated in contact with stationary flat surfaces at frequencies of 60 cycles or less than 1 cycle per second, an amplitude of 0.001 inch, and a load of 0.2 pound. Fretting corrosion was concluded to be caused by the removal of finely divided and apparently virgin material due to inherent forces and that its primary reaction is independent of vibratory motion or high sliding speeds. Fretting corrosion occurred to clean nonmetals and metals readily and glass microscope slides and steel balls provided an excellent method for visual studies. Photomicrographs and 9 references are given.—INCO.

### 3.5 Friction and Wear of Metallic Surfaces. W. J. McG. Tegart. *Australasian Eng.*, 58-68 (1949) Feb.

A comprehensive review of the literature under the following headings: a) mechanism of friction, b) chemical inhomogeneity of metallic surfaces, c) surface temperature of sliding metals and its influence on surface flow and wear, d) types and general mechanism of wear e) wear and physical properties, f) methods of wear prevention, g) wear of steels, h) wear of cast irons, i) bearing metals, j) wear testing. A bibliography of 63 references is appended.—MA.

### 3.5, 6.4

The Effects of Tensile and Compressive Stresses on the Corrosion of an Aluminum Alloy (24S). W. D. Robertson. *Trans. AIMME*, 175, 428-432; discussion, 432-434 (1948). Cf. *Met. Abs.*, 15, 280 (1948).—MA.

### 3.5, 7.1

Stress Corrosion in Radial-Flow Steam Turbines. G. H. Wray. *Engineering*, 169, 141-143, 169-171 (1950) Feb. 10, 17.

Summary of metallurgical investigation on cold-work effects of rolling the dovetail blade fixture, during manufacture of blade rings for Brush Ljungstrom double rotation turbines. Earlier method of construction, now superseded, involved securing some of the blades in such a manner as to require cold-deformation of the steel. Ring dovetails were closed onto individual blades. Original Ljungstrom machines were fitted with blade rings having welded blade construction throughout the radial-flow system; these gave satisfactory performance. Subsequently, a new type of blade ring was introduced in which the rings were built up of individual blades of Ni-Cr-Mo steel (change necessitated by increased stresses to which blade roots were subjected in larger-diameter blade rings for machines of higher output). Difference between welded and individually-bladed construction is illustrated. Rings of welded-blade construction were of 5% Ni steel. It is stated that use of welded blading has been continued in production of smaller-diameter blade rings. Account of examination of sections cut from damaged Ni-Cr-Mo steel blade rings and of laboratory investigations is given.—INCO.

## • Factors Electrochemical

### 3.6

Galvanic Corrosion—What It Is and How It Can Be Avoided. S. B. Ashkinazy and J. M. Joyce. *Mat. and Meth.* (U. S. A.), 31, No. 2, 49-53 (1950) Feb.

Serious galvanic corrosion can result if proper precautions are not taken in product designs where dissimilar metals come in contact with one another. This article explains the essential principles underlying the problem and presents for the guidance of engineers and designers practical measures to prevent such corrosion. The extent of corrosion caused by any galvanic couple is influenced by the following factors: 1) electrode potentials of the two metals, 2) polarization and film forming characteristics of the metals in the corroding solution, 3) relative anode and cathodic areas, 4) Internal and external resistances of the galvanic circuit and, 5) factors that normally influence general corrosion processes. The most practical method of prevention is to select materials which, when coupled, show no strong tendency to produce galvanic corrosion. When it is unavoidably necessary to couple aluminum or magnesium to another metal, protective insulation must be present at all times, the most effective type being a solid gasket material of about 0.010-inch thickness—materials such as Vellatex, synthetic rubbers, ethyl cellulose, nylon and polyethylene.—ALL.

### 3.6

Report of (ASTM) Sub-Committee VIII on Galvanic and Electrolytic Corrosion. *Proc. ASTM*, 48, 167-175 (1948).—MA.

### 3.6, 3.4, 6.4

The Influence of Anions on the Potential of Aluminum in Aqueous Electrolytes. R. Ergang and G. Masing. *Zeitschrift für Metallkunde* (Germany), 40, No. 8, 311-317 (1949) Aug.

Polarization in buffered and unbuffered aqueous solutions of NaBr, NaCl, Na<sub>2</sub>SO<sub>4</sub> and KI solutions are described, as well as effect of temperature and concentration. Potential of aluminum in

aqueous solutions depends on nature and concentration of the anion; in halide solutions the potential increases in the order Cl<sup>-</sup> to Br<sup>-</sup> to I<sup>-</sup>.—ALL.

### 3.6, 6.5

Survey of the Demands on Heat-Resistant Metals and Today's Possible Solutions. (In German.) F. Rapatz. *Archiv für Metallkunde*, 3, 387-393 (1949) Nov.

Survey of literature summarizes results of studies of properties of ferrous and nonferrous alloys at elevated temperatures. Data and results are graphed and tabulated. 10 ref.—BLR.

## • Factors Metallurgical

### 3.7, 6.4

The Effect of Minor Alloying Elements on the Rate of Dissolution of Aluminum in Bases. M. E. Straumanis and N. Brakss. *J. Electrochem. Soc.*, 96, (5), 310-317 (1949).

It is shown that the rate of dissolution of aluminum in 0.5N bases, NaOH, Ba(OH)<sub>2</sub>, and NH<sub>4</sub>OH is increased by the addition of a number of minor alloying elements, particularly those of low hydrogen overvoltage. Platinum is the most active of the metals examined in this respect, followed by iron and copper in that order. These metals act as the cathodes of local elements formed with the aluminum. Up to a concentration of 5%, it is shown that the rate of solution of the aluminum is proportional to the logarithm of the concentration by weight of the alloying element. If the alloying element has a high hydrogen overvoltage, the effect on the rate of dissolution is different, and no simple relationships were found for the other metals examined. The following summarizes the effects of these metals: (1) The rate of dissolution is increased by zinc, cadmium, magnesium, and silicon in NaOH, by cadmium, magnesium, lead, bismuth, and calcium in Ba(OH)<sub>2</sub> and by tin in NH<sub>4</sub>OH. (2) It is not influenced by bismuth or calcium in NaOH nor by zinc or silicon in Ba(OH)<sub>2</sub>. (3) It is retarded by tin, antimony, and lead in NaOH, by tin and antimony in Ba(OH)<sub>2</sub>, and by antimony, zinc, and magnesium in NH<sub>4</sub>OH. Some doubt is cast on the results obtained for silicon in that the sample used contained iron which may have taken an active part. 12 references are appended.—MA.

### 3.7, 6.4

Effect of Heat Treatment on the Corrosion-Resistance of Mg-Base Mg-Al (Magnevin 3515). (In German.) W. Bulian. *Werkstoffe und Korrosion*, 1, No. 1, 10-12 (1950) Jan.

This is the high-strength wrought alloy 7-8%Al, up to 1%Zn, 0.1%Mn. Corrosion tests were based on hydrogen evolution in 0.3% NaCl solution. The corrosion-resistance increases with increasing heterogeneity, such as is brought about by precipitation hardening treatment; it is reduced by homogenizing heat treatment.—BNF.

### 3.7, 6.2

The Principal Properties of the Corrosion-Resisting Steels. A. DeSy. *Mémoires de la Soc. Roy. Belge des Ingénieurs et des Industriels*, Ser. B, 1949, No. 4, 137-154.

Deals with martensitic Cr steels, ferritic Cr steels, austenitic Cr-Ni steels, Cr-Ni steels with  $\gamma$ - $\delta$  structure. Special



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ref. to influence of composition and of modifications in composition is made. Types of corrosive attack to which the steels are subject, and corrosion resistance of the steels are discussed. Conclusion is reached that improvements in performance are more likely to come from increased homogeneity than from effects of special alloy additions.—INCO.

### 3.7

**Non-Corrosive Soldering Flux Paste for Universal Application.** Foster D. Snell, John A. DeRosa, J. Mitchell Fain, and Chester A. Snell, Foster D. Snell, Inc., New York. Second Quarterly Progress Report; U. S. Signal Corps Contract W-36-039-sc-38216 (1949) July.

Continued research aimed at the development of a universally applicable, noncorrosive soldering flux paste resulted in three acceptable resin-aluminum stearate preparations and four plasticized resin flux compositions, all for use in cored solder.

The three resin-aluminum stearate paste formulations contained 44% Nuroz (partially polymerized rosin), 2% cetyltrimethylammonium bromide (CTAB), 4% aluminum stearate, and 50% solvent. Based on soldering efficiency, consistency, and corrosion resistance, the paste containing tetralin as the solvent was judged to be better than those with turpentine oil or Solvesso-150. The fluxing efficiency, however, of even the best of these three pastes when applied in a cored solder was surpassed by several commercial cored solders.

Plastic cored solders, especially those based on Nuroz and Rosin Dimer, were generally more efficient than paste cored solders. Plastic cored solders contained Teglac 128 resin were the least efficient of those tested except for one commercial solder containing Rosin Dimer. The four compositions developed were 1) 71% Teglac 128 resin, 3% CTAB, 3% glycerol, and 23% amyl acetate; 2) 51% Teglac 128 resin, 2% CTAB, 2% glycerol, and 45% turpentine oil; 3) 80% Nuroz, 3.2% CTAB, 2.8% rosin oil, and 14% turpentine oil; and 4) 69% Rosin Dimer, 3% CTAB, 3% rosin oil, and 25% turpentine oil. In all these formulations, ethylhexadecyldimethylammonium bromide can be substituted for CTAB.

Preparations containing boron trifluoride, combined either with 1) Nuroz or Rosin and a quaternary ammonium compound or with 2) triethanolamine showed some promise, but were too corrosive.—PDA.

## CORROSIVE ENVIRONMENTS

### Chemicals Inorganic

#### 4.3, 6.2, 6.3

**Corrosion of Metals Under Action of Hydrocarbon Solutions of Iodine.** (In Russian.) L. G. Gindin and M. V. Pavlova. *Doklady Akademii Nauk SSSR* (Reports of the Academy of Sciences of the USSR), new ser., v. 69, 377-380 (1949) Nov. 21.

The above was investigated for Cu, Pb, and Fe, using benzene and isooctane solutions of iodine. Method of investigation is described. Data are tabulated.—BLR.

#### 4.3, 6.4

**Surface and Stress Corrosion Stability**

**of Aluminum Alloys Subjected to Salbei (Concentrated Nitric Acid).** Schaar. *Werkstoff Bericht*, Mar. 1943, No. 1/1/43, 21 pp. Air Material Command, Wright-Patterson Air Force Base, Translation No. F-TS-1860-RE, Sept. 1948, ATI No. 18772.

Pure Al, Duralumin, Al-Mg, and Al-Mg-Si are resistant to corrosion by 98% HNO<sub>3</sub> at temperatures of 0-15° C in stressed and unstressed states. Zn-Al alloy shows tendency toward slight insignificant pitting in unstressed state; this pitting increases during plastic and elastic deformation in such a manner that practical application is possible only for parts requiring limited use. Photographs and tables are given.—INCO.

### Chemicals Organic

#### 4.4

**Surface Attack of Metals by Fatty Acids and the Formation of Lubricating Layers.** D. Tabor and E. D. Tingle. *Surface Chemistry* (Special Suppl. to Research), 1949, 217-220 (In English); 220-222 (in French).

It is shown that the view that boundary lubrication of solids is due to physical adsorption of lubricant molecules at the solid surfaces is an over-simplification. On this view, the function of the lubricant is to mask or saturate the fields of force of the solid surfaces, the interaction between these fields of force being the cause of friction. Since polar molecules are more strongly adsorbed, these were considered to be more effective than non-polar. The paper shows that on non-reactive surfaces, such as silver or platinum, fatty acids (polar bodies) are no more effective as boundary lubricants than paraffins or alcohols of about the same chain length, i. e., they produce a low coeff. of friction only when solid. Above their m.p. there is a marked increase in friction and surface damage. On the other hand, on reactive metals the surface damage and coeff. of friction remain low at much higher temp; in fact, up to approx. the temp. of melting or softening of the metallic soap formed by chemical reaction at the surface. As the results show that a solid hydrocarbon is more effective than a molten fatty acid on a non-reactive metal, lateral adhesion between the lubricant molecules is of great importance and physical adsorption of lesser importance in reducing friction. It is suggested that metallic soap films are not formed by direct reaction with the metal, even with electro-negative metals, nor with the oxide film in the absence of water, but that for adequate soap formation the presence of water during the formation of the oxide film is necessary.—MA.

### Soil

#### 4.5, 5.4, 3.3

**Varnishes and Paints in Tropical Climates.** H. Rabate. *Peint. Pig. Vernis*, 25, No. 10, 369-70 (1949).

While paints in tropical climates do not in general have to withstand the corrosive atm. associated with industrial areas, they must stand up to rapidly changing high temps., high humidity (which encourages biological attack), light, and in some cases, the abrasive action of sand, etc. Biological attack is combated by means of fungicides and

the action of sand by suitable choice of pigments. The addition of silicones is advantageous.—RPI.

#### 4.5, 8.9

**Correlation Between Corrosion Survey Results and Actual Conditions as Determined Through 130 Miles of Continuous Reconditioning.** I. B. Tietze. Paper before NACE, 5th Ann. Conf., Cincinnati, Apr. 11-14, 1949. *Corrosion*, 5, No. 12, 409-414; Disc. 414-415 (1949) Dec.

The corrosion survey has been used for many years as a means of locating corroded sections of pipe line. Although records were kept of leak locations and conditions of pipe wherever uncovered for repairs or inspection, no conclusive evidence as to the accuracy of the survey was obtained. The continuous reconditioning of sizeable lengths of lines afforded a better means of determining this accuracy, and consequently provisions were made to gather necessary data while the lines were uncovered for reconditioning. The paper is concerned with correlation of data pertaining to pipe condition obtained during continuous reconditioning with corrosion survey recommendations. In addition to the correlation study, certain data are indicative of the effectiveness of a spot-reconditioning and coating program which had been followed in the past. Many tables and charts are given.—INCO.

### Water and Steam

#### 4.6, 8.4

**Corrosion and Chemical Testing of Waters for Subsurface Injection.** J. W. Watkins. *Producers Monthly*, Part 1, 15-19 (1950) Feb.

This article describes in detail methods of corrosion tests and chemical analyses that have been used extensively and satisfactorily in a study of plants that condition various surface waters and brines used for water flooding, brine disposal, and reservoir pressure maintenance in Kansas, Oklahoma, and North Texas. The tests and analyses described were adapted and designed to be used in the field for determining the relative corrosive and plugging tendencies of waters from various sources conditioned by different methods.—GPC.

#### 4.6, 3.3

**A Practical Approach to the Problem of Cooling-Water Slime.** R. B. Wise. *Oil and Gas J.*, 48, 170+ (1950) Feb. 23.

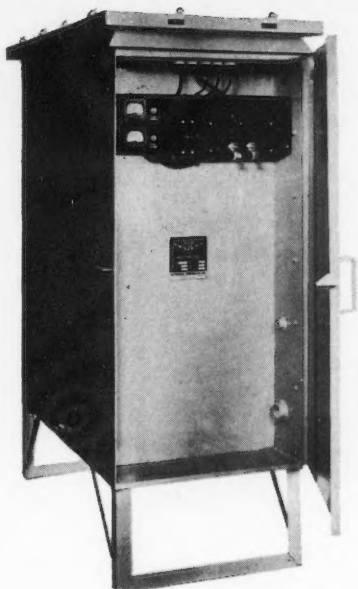
The three main groups of organisms which may give trouble in recirculating cooling-water systems are algae, bacteria and fungi. The mere presence of "bugs" in the water is not trouble; trouble is caused only by that portion that tend to clump together and form slimy deposits. Somewhat contrary to common belief, algae are usually the least troublesome of the three groups in modern recirculating cooling systems. This discussion gives the subdivisions of each of these three main groups, describes the occurrence and action of each subdivision, and lists the trouble-making organisms.—GPC.

#### 4.6, 6.4, 2.3

**The Attack of Zinc by Hot Tap Water.** G. Schikorr. *Z. Metallkunde*, 40, No. 9, 344-348 (1949) Sept.

Corrosion of specimens of 98.5 Zn

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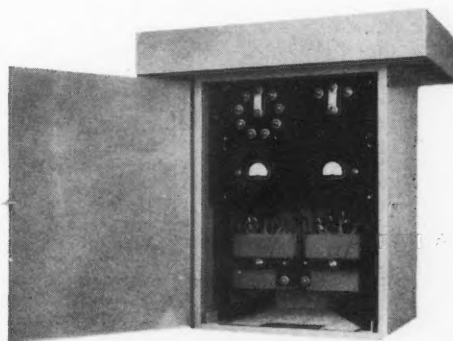
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sheet in four kinds of tap water at  $70^{\circ}\pm 2^{\circ}$  C was determined. The waters were a)—a pure water with  $2^{\circ}$  total hardness and  $2^{\circ}$  carbonate hardness; b)—a) +360 mg NaCl per l; c)—a) +370 mg Ca SO<sub>4</sub> per l; and d)—normal water containing approximately 106 mg per l CaO, 9 MgO, 36 combined Cl, 27 combined SO<sub>4</sub>, 13 free CO<sub>2</sub>, 84 combined CO<sub>2</sub> and 116 combined HCO<sub>3</sub>. The pH of d) was approximately 7.3 and a), b), and c) approximately 6-7. Volume of water was 6.5 cu. cm. to 1 sq. cm. of specimen and access of air was prevented by sealing glass jars. After 180 days, the order of severity of general corrosion, estimated by weight loss, was c), b), a) and d; the order of pitting after one year was c), b), and a) approximately equal, and d). Corrosion was greater when carbonate water was renewed infrequently than when renewed often.—INCO.

## PREVENTIVE MEASURES

### • Cathodic Protection

#### 5.2, 8.9

**Rust Protection by Magnesium Anodes Boosted.** *Steel*, 125, No. 23, 68 (1949) Dec. 5.

To prevent pitting of steel bottoms in salt water, the Maritime Commission will apply cathodic protection to 2200 cargo ships in the National Defense Reserve Fleet. This will be done by attaching a cable to a magnesium anode and suspending it over the side of the ship. The technique and materials are described and it is stated that the expected cost is approximately one-half that of sandblasting and painting the hulls.—ALL.

#### 5.2

**The Galvanic Protection of Buried or Immersed Metallic Structures by Magnesium Anodes.** Bernard J. C. Raclot. *Metaux et Corrosion*, 23, No. 271/272, 98-102 (1948).

The theory of galvanic corrosion protection, advantages of magnesium over zinc anodes, influence of soil pH, anode composition and cd, method of using magnesium anodes, and some test results, are discussed.—MA.

#### 5.2, 4.6

**Methods for Prevention of Rust in Water Tanks.** A Preliminary Report, Fred Schumann, Electronic Consultants, Nashville. *Corrosion*, 5, 198-200 (1949) June.

A protective coating combined with cathodic protection is suggested for preventing the rusting of water tanks. It is estimated that in such a system, a uniformly thick, bituminous coating applied to a thoroughly cleaned surface would deteriorate at the rate of only about 0.01 in. per yr. When local pinhole faults exposing small areas of bare metal develop, the electrolytic protection equipment would automatically pass a small amount of current at a high current density to the defect. This current plates the exposed part with calcium bicarbonate and other materials and seals it against corrosion until the tank is repainted. After the plating is completed the current again drops to a low value. Because the amount of current is small, only a negligible amount of dissolved oxygen would be formed, thus overcoming one of the major faults of electrolytic protection when used alone. Complete rust and scale removal prior to insulating is essential for satisfactory performance.

This proposed method requires only a

small cathodic protection unit with small anodes. The life of the unit should be very long since it functions only sporadically. Power cost would be extremely low.

This study was based on extensive coverage of available literature and analysis of known facts.—PDA.

### • Metallic Coatings

#### 5.3

**Tentative (ASTM) Methods of Test for Local Thickness of Electrodeposited Coatings (A219-45T).** ASTM Specifications and Tests for Electrodeposited Metallic Coatings, 1949, 24-30.—MA.

#### 5.3

**Nickel and Chromium Plating Compared.** Jerome L. Bleiweis. *Metal Prog.*, 57, 200-202 (1950) Feb.

Surveys the two processes, their properties and applications.—BLR.

#### 5.3, 7.6

**New Techniques for Lining Vessels for Protection Against Corrosion.** G. C. Carpenter. *Petro. Proc.*, 5, 21-25 (1950) Jan.

A series of experiments with methods for applying corrosion-resistant liners to refinery vessels resulted in the development of a new technique, stud-welding, which is to be further tested in the field. As a result of the experiments, plug welding was discontinued in practice and various types of strip welding are now used, depending on temperature and other conditions. The selection of liner materials may be a complex problem, it has been learned, in which conditions of the specific application are the most important factor.—GPC.

#### 5.3

**Surface Preparation of Mild Steel.** Institution of Mechanical Engineers. *The Engineer*, 580-1 (1949) Nov. 18.

An account of the discussion which followed W. A. Johnson's paper above (see ZDA Abs. No. 50/103). W. E. Ballard described the automatic metal spraying plant recently installed at Dudley and gave details of average costs which were higher than those quoted by the author. W. J. Nicholls spoke of the enormous savings which had been effected over the past 20 years by having the steel towers for the British Grid System galvanized. T. P. Hoar thought that more emphasis had been laid on the use of aluminum as compared to zinc than was justified by all the facts, as in some circumstances zinc coatings were of more value; he suggested that the use of zinc-aluminum alloys might be even more effective.—ZDA.

#### 5.3, 3.4

**A New Method of Protecting Metal in Electrolytes by Covering with a Monatomic Layer of a Nobler Metal.** (In German.) O. Erbacher, W. Herr, M. Ebert and H. von Babo. *Archiv Metallkunde*, 3, No. 12, 409-413 (1949) Dec.

Ni is covered with Bi by immersion in concentrated HCl containing some Bi; Zn with Cu by immersion in 0.05N ammonia containing Cu; Fe with Cu from tartrate. In each case it is shown that the layer of nobler metal produced protects the basis metal (Ni protected against HCl, Zn against ammonia solu-

tion, Fe against sodium potassium tartrate).—BNF.

#### 5.3, 5.4

**Practical Uses of Different Types of Protective Coverings.** U. R. Evans. *Ind. Fin. (U.K.)*, 2, No. 17, 261-70 (1949) Nov.

A reprint of part of the author's book, "An Introduction to Metallic Corrosion" (pp. 163-73). A review of the particular applications of the noble metals, nickel, chromium, tin, lead, zinc, aluminum, cadmium, indium, glassy enamels, stoving enamels, oil paints, zinc chromate, chlorinated rubber and polystyrene paints and tar and bituminous paints, when used as protective coverings. The way in which the Crapo process reduces the brittleness of galvanized coatings is outlined and the importance of uniform coatings stressed. Zinc plated wire, small Sherardized articles and zinc sprayed steelwork are also mentioned. Cadmium coatings are especially valuable in hot and humid tropical conditions. Zinc chromate, it is stated, has superior keeping power to red lead and is not seriously inferior as a corrosion inhibitor. Chlorinated rubber paints are often pigmented with zinc dust and so provide, in effect, a form of galvanized coating which can be applied on site.—ZDA.

#### 5.3, 5.9

**Present Status of Pickling and Hot Galvanizing.** R. Haarmann. *Stahl und Eisen*, 69, 734-739 (1949).

Review of literature on pickling and hot dip galvanizing, covering the past ten years. Recovery of spent acid baths, methods for testing pickling solutions and of heating galvanizing kettles, summary of results of theoretical studies of Fe-Zn reaction and of influence of Al, Cu and Cd contents of Zn bath and C and Si contents of steel upon Zn coating, advantages of surface roughness of base metal, best way of insuring good adherence to steel wire, ductility of Zn coatings, new method of determining coating thickness, new processes for galvanizing tubing and wide strip, and possibilities of economizing on Zn at galvanizing shops are discussed. 48 references.—INCO.

#### 5.3

**Causes and Control of White Rusting on Zinc Coated Sheets.** G. R. Hoover and Arba Thomas. American Iron and Steel Institute, "Technical Committee Activities," 1949, 243-251.

Describes three ways, other than keeping the sheets dry, by which the above can be delayed or reduced in intensity.—BLR.

#### 5.4

**Improved Coating for Magnet Wire.** R. Reading, Belden Mfg. Co. *Elec. Mfg.*, 45, No. 3, 118+ (1950) Mar. See also: Wire Stripping Practice on Coil Leads, by R. G. Roesch, *Ibid.*, 104 (1949) July.

Coating of nylon over vinyl acetate for Cu magnet wire insulators eliminates solvent crazing, increases abrasion and solvent resistance, and withstands softening effects of elevated temperatures. One of these coated wires is Nyclad, another Formvar. Manufactured by Belden Mfg. Co.—INCO.

#### 5.3

**The Protection of Steel by the Powder Process of Flame Spraying.** C. A.



Robiette. *Ind. Fin.* (Lond.), 2, No. 16, 220-228 (1949).

The use and properties of flame-sprayed aluminum and zinc coatings for the protection of steel surfaces are described. Aluminizing, whereby the sprayed aluminum component is heat-treated (800° C) to produce a protection for high-temp. service, is also briefly mentioned. Numerous industrial applications are given, together with an indication of the equipment required and the costs involved in flame spraying.—MA.

5.3 **Electrodeposition of Chromium-Tungsten Alloy Plates.** Donald G. Rogers and Arthur A. Burr. *J. Electrochem. Soc.*, 97, 67-69 (1950) Feb.

From a solution of 2 M. chromic acid, reduced to a trivalent Cr content of 40% with 300 g/l of ammonium citrate and containing 150 g/l of tungstic anhydride, alloy plates of Cr and W of thicknesses up to nearly 0.0001 in. were deposited at a temperature of 60-75° C. The plates have excellent appearance and resistance to corrosion by any of the common inorganic acids.—BLR.

5.3 **The Influence of Base-Metal Surfaces on the Nature and Characteristics of Electrodeposited Metals.** A. T. Steer. *Australasian Eng.*, 1949, 38-53 (1949) Sept.—MA.

5.3 **Galvanizing Processes.** J. F. Stirling. *Pract. Eng.*, 19, No. 473, 176-178 (1949).

Describes the properties of zinc and its use on iron and steel parts for corrosion protection.—MA.

5.3 **Sprayed-Metal Films.** J. F. Stirling. *Pract. Eng.*, 19, No. 490, 668-670 (1949).

A general account is given of the process, its historical development, and the metals that may be sprayed. The properties of sprayed films and the uses of the process in industry are discussed.—MA.

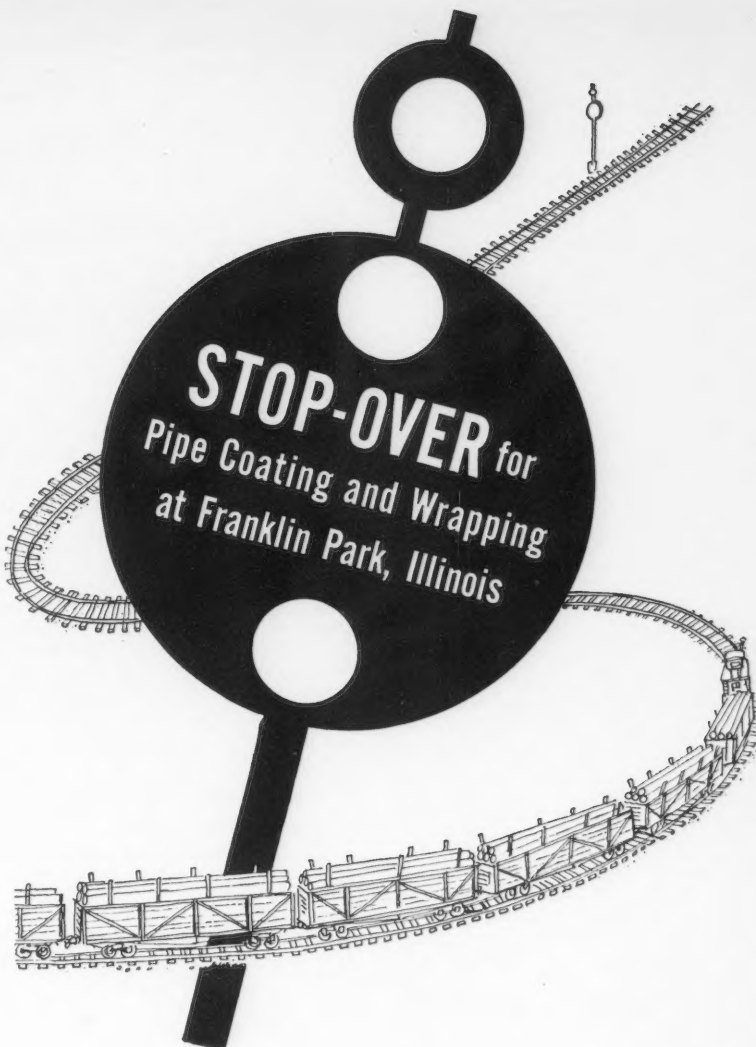
5.3 **Electroplated Coatings for Corrosion Protection.** A. G. Sussex. Paper delivered to the Australian Institute of Metals, Melbourne Branch. *Electroplating*, 3, No. 3, 97-99+ (1949) Nov. *Australasian Eng.*, 1949, 37-42.

Relative corrosion rates of non-ferrous metals; corrosion promoting and controlling factors; wear of electrodeposited coatings; protection by Zn, Cd and Ni-Cr coatings; role of alloy plating in provision of improved protection. 32 references.—BNF.

5.3 **From a Metallurgist's Notebook: Cadmium Plating Defects.** H. H. Symonds. *Metal Ind.*, 76, 43-44 (1950) Jan. 20.

Determination of the origin of certain spots on Cd-plated steel shutters involved investigation of the trichlorethylene used for initial degreasing, the petroleum jelly for lubrication of moving parts, the paper envelopes in which the shutters were normally sealed, and other factors before the conclusion was reached that spotting was caused by accidental application of a corrosive liquid carried in finely divided form in the atmosphere.—BLR.

5.3 **Some Characteristics of Sprayed Metal.**



Pipe can be shipped from eastern mills on through rates to destinations west, northwest, and southwest with stop-over privilege at our Franklin Park, Illinois, plant for cleaning, priming, coating and wrapping. Over 20 acres available to store your pipe as long as one year before re-shipment.

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G. Tolley. *Metallurgia*, **38**, 263-66 (1948); *Prev. Det. Abs.*, **7**, Met 20 (1949).

Some salient features of metal-sprayed deposits are outlined. These coatings have been used to replace red-lead primer as corrosion protectives and they provide an excellent surface to which only the finishing coat need be added.—RPI.

### 5.3

**A Semi-Bright Nickel Plating Process.** Karl S. Willson and A. H. DuRose, Harshaw Chemical Co., Cleveland, Ohio. *Metal Fin.*, **47**, No. 2, 55-57 (1949) Feb.

A new commercial nickel-plating process yields deposits of modified crystal structure, characterized by semi-bright luster, good buffability, and unusual capability to fill in surface irregularities. Semi-bright nickel combines many of the desirable characteristics of both gray and bright nickel platings and offers new possibilities of improved finishes for various applications.

The plating bath, a Watt-type solution, usually contains 40-45 oz. per gal. of nickel sulfate, 6 oz. per gal. of nickel chloride and boric acid, and 0.75-1 lb. of addition agent per 100 gal. of solution. The operating temperature of the bath is 120-135 F. The pH is maintained at 3.5-4.5 by the periodic addition of sulfuric acid. The wide range of all plating factors simplifies control of operation. Special equipment is necessary for plating at higher temperatures.

The addition agent, because of its limited solubility in the plating bath, is customarily charged hourly or once per shift into a suitable filter through which the plating solution is circulated. If the bath temperature is above 140 F, the solution must be cooled before entering the filter to prevent melting of the addition agent, unless this is frequently added in small amounts.

Practically continuous filtration, at a rate equivalent to complete filtration every 1-2 hr., is necessary to insure against roughness and difficulties resulting from the more or less continuous precipitation of ferric ions in the solution. Other metallic impurities, such as copper, zinc, and organic materials, which may increase the stress and reduce the luster on low current-density areas, should be kept at limits similar to those for other nickel baths, using either electrolytic purification, or hydrogen peroxide, activated carbon and high pH in various combinations.

This new plating process is estimated to cost about the same as procedures using standard bright nickel solutions, but the former involves large savings of material and labor for polishing and buffing.

Unlike gray nickel, the semi-bright nickel plate requires only a light pressure on the color buffing wheel to bring out full brightness. The new deposits are well suited for electrobuffing, although a bloom sometimes develops during chromium plating, as with other types of electrobuffed nickel deposits. Semi-bright nickel is intermediate in hardness between gray and bright nickel. Its corrosion resistance both in salt spray and field tests is comparable with other satisfactory types of nickel platings. Stress in the new deposits is similar to that in gray plate from a Watts-type bath. Tensile strength varies between 100,000 and 240,000 psi, depending on operating conditions.—PDA.

## • Non-Metallic Coatings and Paints

### 5.4, 2.2

**An Investigation of Primers for Marine Atmospheric Environments.** C. J. Vander Valk. *Off. Digest* (U. S. A.), No. 292, 260-71 (1949) May.

The object of this investigation, carried out by the Red Lead Technical Committee of the Lead Industries Association, was to find the best modifying pigments and the most effective vehicle for red lead paints exposed to sea air. The test panels were covered with two coats of primer and one finishing coat and exposed for three and a half years. The author concluded that red lead base primers can be improved by the addition of limited amounts of zinc yellow—15 percent by volume being the optimum.—ZDA.

### 5.4

**Fluorescence and Photo-chemical Activity of Zinc Oxides.** G. Winter and R. N. Whitem. *Paint Notes* (Australia), **4**, No. 7-8, 252-61 (1949) July-Aug.

It is suggested that accelerated oxidation of the oil in the paint film is a major factor in chalking. It follows that the different behavior of various types of zinc oxide is due to the way in which the particles dissipate the ultra-violet energy they have absorbed, since all types of oxide do absorb energy in this fashion. These authors have found that there is fairly good correlation between fluorescence and the chalking characteristics of zinc oxides. Suggested mechanisms are put forward, but at present there is insufficient experimental evidence to confirm any of these.—ZDA.

### 5.4

**Painting of Structural Steelwork.** British Iron and Steel Research Association, Second Interim Report of Joint Technical Panel J/PI. Demy 4to. Pp. 16, Illustrated. 1949. London: The Association, 11 Park Lane, W. I. (Gratis).

### 5.4

**Protective Coatings for Weathered Galvanized Sheets.** M. L. Burgener and Deane G. Carter. *Agricultural Eng.*, **31**, 67-70 (1950) Feb.

Summarizes results of experimental test program conducted by American Zinc Institute since 1932, using a wide variety of paints and metal-pigment coatings.—BLR.

### 5.4, 3.3

**Flame Application of Ship Bottom Paints.** W. R. Dowd. U. S. Naval Shipyard, Mare Island, Calif., **1948**, Oct. *Prev. Det. Abs.*, **6**, Lac 28 (1949).

Anti-fouling ship paints (apparently formerly applied as a thermoplastic coating 30 ml thick) can be flame-sprayed as powders to give an effective coating 7 ml thick. Paint is powdered by spraying hot liquid down a 40 ft. shaft and screening the dust to retain the fraction smaller than 40 mesh. The paint is sprayed in a Schori gun with an oxy-propane flame, at 90 lb./in.<sup>2</sup> pressure and with a nozzle temp. of 300-400° F.—RPI.

### 5.4, 2.3

**Testing the Durability of House Paint Systems for Outdoor Use.** A. C. Elm.

*Paint, Oil and Chem. Rev.* (U. S. A.) **1949**, 16-8+, May 12.

The author begins by analyzing the factors which have to be taken into account in outdoor exposure tests—uncontrollable weather, the way in which the paint is applied, the conditions of drying and the underlying surface. The next part of the article is devoted to a discussion on statistical and graphical methods of analyzing the results of exposure tests: the author suggests that only by integrating the breakdown-time curves can true comparisons of performance be obtained. He obtained an overall durability value by adding together the checking rating, twice the cracking rating and three times the sum of the erosion, scaling, peeling and flaking ratings. After advocating the use of a large number of panels to obtain reliable results, he criticizes accelerated weathering tests on the grounds that they do not reproduce the arbitrary combination of different elements which make up natural weather. The article concludes with notes on recent work designed to allow earlier detection of film deterioration.—ZDA.

### 5.4, 2.2

**Weathering Tests on Zinc Oxide Paints.** J. R. Rischbieth. *Paint Notes* (Australia), **4**, No. 7-8, 225-37 (1949) July-Aug.

In the first exposure trials, paints containing indirect process zinc oxides early developed serious chalking and rapid loss of gloss; and these differences persisted even after 70 weeks' exposure. The second series of trials was more extensive and included various white lead-zinc oxide, zinc oxide, and zinc oxide-titanium dioxide formulations, with or without extenders. Again in all formulations except zinc oxide-iron oxide, indirect process oxide paints not only chalked and lost gloss earlier than corresponding paints containing direct process oxides, but also checked and cracked more rapidly. The author concluded that the gloss retention of zinc paints is better than that of white lead paints. It was also found that the acid value of the vehicle, over a range 0-12, had no significant effect on early chalking, but that the inclusion of bodied oil in the vehicle was advantageous in almost every case. A third series of exposure tests included 20 different samples of zinc oxide manufactured by various processes—and here again larger particle oxides showed better resistance to chalking. The absence of severe early chalking in Britain is attributed to the milder climate.—ZDA.

### 5.4, 2.2

**New Marine Primers.** K. H. Roll and C. J. V. Valk. *Mar. Eng. and Shipping Rev.*, **54**, No. 3, 51-3 (1949) Mar.

An account of some exposure tests carried out by the Red Lead Technical Committee of the Lead Industries Association to determine the best formulation for marine priming paints containing red lead. A total of 99 pigment combinations and 88 different vehicles were tested over a period of two years for total immersion and for tide range exposure. Two topcoats of antifouling paints to U. S. Maritime Commission specifications were applied in each case. Some of the primers which contained red lead as the principal rust inhibitive pigment gave results as good as, or better than, those obtained with zinc chro-

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mate primers to U. S. Navy specification 52-P-18 and U. S. Maritime Commission specification 52-MC-29. Nearly all the best formulations tested contained at least 10 percent zinc chromate and often 10 percent zinc oxide. The authors lay great stress on the scientific nature of the tests, and their simulation of actual service exposure conditions.—ZDA.

#### 5.4, 8.9

**The Field Performance of Modern Asphaltic Pipe Coatings.** G. N. Scott. *Oil and Gas J.*, 48, 68+ (1950) Jan. 12.

The purpose of this report is to show from test and examination what has been accomplished and what further steps can be taken to insure perfect or almost perfect performance of the asphalt-mastic coatings. The two principal tools employed to study laid coatings and to follow their behavior are: 1. the coating-discontinuity survey; and 2. the coating conductance as determined by a few simple measurements on the gross structure. The conductance of segments of coating is sometimes measured directly in the field or in the laboratory.—GPC.

#### 5.4

**Moisture-Resistant Coatings for Metals.** William F. Singleton and William C. Johnson. *Ind. and Eng. Chem.*, 41, No. 4, 749-753 (1949).

The paper presents data on the permeability, adhesion to certain metals, and moisture-resistance under alkaline conditions, for a range of polymeric coatings, the specific problem concerned being the development of an improved sealing coat for metal objects which would be exposed continuously to moisture-saturated atmospheres in the presence of small concentrations of ammonia. Selected coatings were pigmented to determine the effect of the type and concentration of pigment. The polymers show a practical advantage over a phenolic-tung oil coating because of superior resistance to alkali, although the permeability is in the same range as the phenolic varnish. Inert pigments offer some improvement over unpigmented films both in adhesion and permeability. The effect of pigmentation is less than would be obtained on oleo-resinous films, and optimum pigment concentration is lower.—MA.

#### 5.4, 3.5, 6.3

**High-Temperature Ceramic Coatings Developed for Molybdenum.** *Steel*, 124, No. 4, 59, 82 (1949).

Experiments at the National Bureau of Standards have been directed towards the development of ceramic coatings for high-m.p. metals, as protection against oxidation at high temp. Preliminary results indicate that molybdenum is a suitable subject.—MA.

#### 5.4, 4.4

**Protective Coating for Fatty Acids.** K. Tator. *Chem. Eng.*, 56, No. 9, 230, 231 (1949).

Fatty acids may suffer contamination from unprotected iron or lead pipes and these are preferably painted. The type of medium is limited by the strong solvent action the acids possess, consequently a baked finish is desirable, e.g., phenol/CH<sub>2</sub>O (which are preferred) and Vi or vinylidene chloride finishes.—RPI.

#### 5.4

**Discussion of Protective Finishing of Electrical Equipment.** J. Widnall & R. Newbound. *J. Inst. Elec. Eng.*, 95, Pt. 2, No. 48, 695-702 (1948). *Paint Notes*, 4, No. 4, 132 (1949).

Discussion of a paper previously noted (*Review*, 1947, 2227).

The application of a green chromate primer followed by a yellow chromate coat and a grey-pig. alkyd enamel finish proved effective in protecting the external ironwork of grid installations.—RPI.

### ● Treatment of Medium

#### 5.7

**Some Application Factors Affecting the Regulation of pH in Industry (cont.).** A. L. Chaplin. *Instruments*, 22, No. 9, 804-806, 838-854 (1949) Sept.

Some application factors are described which affect the regulation of the hydrogen ion concentration in chemical processes of industry. The type of electrodes and sampling system which are common in industrial applications are discussed. These are the submersible assembly and the outboard flow assembly. The submersible assembly is generally preferred for application to open tanks, and has the advantage that transfer and detection lags are minimal when the electrodes are in direct contact with the tank liquors. The importance of electrode sampling lines being installed with exact design specifications and engineering appraisal is emphasized. In some cases, the problem of sampling strongly corrosive liquors in buried or below-floor tanks presents an acute problem requiring costly alloy sampling pumps or special techniques for withdrawing the sample.—TDD.

#### 5.7

**Protective Atmospheres in Industry—Pt. I-XIII.** A. G. Hotchkiss and H. M. Webber. *Gen. Elec. Co. Gen. Elec. Rev.*, 51, No. 11, 12, 29-35; 41-48 (1948) Nov., Dec.; 52, No. 2, 12 ind., 37-44; 25-30; 25-28; 30-37; 33-41; 32-40; 26-29; 38-43; 30-37; 46-54 (1949) Feb.-Oct., incl., Nov., Dec. 53, 2, 43-50 (1950) Feb.

Review of how and where protective atmospheres are used. Atmospheres used for preventing or reducing oxides are discussed. The uses, properties, methods of distribution, and equipment used in purification of combusted fuel gas are covered. Effects of furnace atmospheres of H<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>, or dissociated NH<sub>3</sub>, and combusted and catalytically reacted fuel gases in preventing decarburization in various heating processes are described. Importance of dew point and other atmospheric conditions in obtaining desired C penetration, concentration, or restoration are discussed. Descriptions are given of a variety of typical instruments used for analyzing, controlling and measuring various industrial gases. Methods by which surplus gases can be accumulated and stored are given. Typical heat treatment applications including hardening, electric furnace brazing, powder metallurgy, gas carburizing and bright annealing metals, such as stainless steel are described. Data on applications and recommended protective atmospheres for various steels, including stainless steels and Cu-Ni alloys are tabulated. S in amounts permitted, in city gas systems, is not harmful to ferrous metals, but it has the tendency to blacken Cu and Ag and to embrittle Ni.

Photomicrograph of carburization throughout thin sheet of 18-8 alloy, and section of Inconel tubing showing carburization is included. 42 references.—INCO.

#### 5.7, 4.6

**Degassing of Water as a Preventive Against Corrosion.** K. Wickert, K. Nollen, J. Kroll, and E. Ipach. *Arch. Metallkunde*, 3, No. 3, 105-113 (1949).

The paper is in three parts: I. Experiments on the oxidation of sodium sulfite by molecular oxygen in neutral aqueous solutions. II. Experiments on the oxidation of sodium sulfite by molecular oxygen in alkaline aqueous solutions. III. Experiments on the oxidation of hydrazine by molecular oxygen in pure water. Experiments on the removal of dissolved oxygen from boiler feed water and condensate are described in detail. The reaction rate between sodium sulfite and molecular oxygen is slower in alkaline than in neutral solutions. The resulting products are not actively corrosive if the treatment is carried out between 20° and 80° C; at the latter temp. excess sulfite should be avoided lest intermediate products of a corrosive nature be formed. Treatment with hydrazine gives a faster reaction than with sulfite in alkaline solutions, but it is slower than with sulfite in neutral solutions. The reaction products, nitrogen and water, are non-corrosive, and the method is very suitable for the removal of residual oxygen left behind after other treatments.—MA.

### ● Inhibitors and Passivators

#### 5.8, 8.4

**Combats Sulfide: Corrosion Inhibitor (165a).** *Chem. Eng.*, 57, No. 3, 165-166 (1950) Mar.

A new inhibitor for sulfide corrosion in producing oil wells is called Corexit. This is a free-flowing liquid, has no objectionable odor, is non-toxic, and is available at reasonable cost. Tests on this inhibitor show that it gives satisfactory corrosion resistance at a cost of fifty cents to one dollar a day. Mfg. by Humble Oil & Refining Co.—INCO.

#### 5.8

**Effect of Adsorbed Polar Organic Compounds on Activity of Steel in Acid Solution.** Norman Hackerman and E. L. Cook. *J. Electrochem. Soc.*, 97, 1-9 (1950) Jan.

A series of aliphatic acids, amines and esters and one commercial corrosion inhibitor were adsorbed from benzene solution onto SAE-1020 steel powder. These studies (reported elsewhere) showed that some portion of the sorbed material, depending on the compound, could not be desorbed by fresh solvent. The present work was concerned with the effect of the adsorbed material on the activity of the steel powder in aqueous HCl. Ratio of the activity to that of untreated steel powder was found to depend on compound adsorbed and on the type of adsorption.—BLR.

#### 5.8

**Concerning the Passivating Action of Halide Ions on Iron in Concentrated Acid Solutions.** (In Russian.) Z. A. Iofa and L. A. Medvedeva. *Doklady Akademii*

*Nauk SSSR* (Reports of the Academy of Sciences of the USSR), new ser., 69, 213-216 (1949) Nov. 11.

The inhibitive effect on dissolution of iron in acid solutions caused by a series of inorganic inhibitors, particularly those containing halide ions, was investigated. Results indicate that this effect is caused by formation of a surface layer consisting of an iron-halide compound (probably monomolecular). Data are tabulated and charted.—BLR.

## 5.8.4.4

**Rust Inhibitor.** *Rev. Sci. Instrument*, 21, No. 2, 198 (1950) Feb.

Santolene C is a hydrocarbon, water soluble, non-metallic organic compound and is used as a rust inhibitor for gasoline, fuel oil and other light oil products in pipe lines and static storage. 0.002% is effective in distilled water and 0.01% in sea water. Mfg. by Monsanto Chemical Co.—INCO.

## 5.8

**Mechanism of Protection of Iron from Corrosion in Water by Means of Chromates. Effect of Potassium Dichromate Additions to Water Upon Electrode Potential of Iron.** I. L. Rozenfel'd and G. V. Akimov. *Doklady Akademii Nauk SSSR*, 67, No. 4, 667-669 (1949). PPL (Translation available from Henry Bratcher, P. O. Box 157, Altadena, Calif.).

Discussion of action of chromates as depolarizers in cathode process vs inhibitors in anode process, film theory as an explanation of the protective mechanism involved, numerical data on influence of potassium dichromate additions to water upon electrode potential of Fe as function of time, and range of dichromate concentration conducive to a baser potential of Fe and underlying cause. 5 references.—INCO.

## 5.8

**Mechanism of Protection of Iron from Corrosion in Water by Means of Chromates. Effect of Potassium Dichromate Additions to Water Upon the Rate of Electrode Processes.** I. L. Rozenfel'd and G. V. Akimov. *Doklady Akademii Nauk SSSR*, 67, No. 5, 879-882 (1949). (Translation available from Henry Bratcher, P. O. Box 157, Altadena, Calif.).

Experimental study of kinetics of electrode processes with special reference to the possibility of a reduction of potassium dichromate in neutral and weakly alkaline solutions on micro-cathodes, and its serving as depolarizer in cathode process. Nature of mechanism of action of chromates as corrosion inhibitors and connection between this mechanism and the existence of an adsorbed layer of chromate ions on iron are discussed.—INCO.

## 5.8

**Sodium Metaphosphate as Corrosion Inhibitor for Iron: Effect of Oxygen and Chloride.** H. H. Uhlig and H. C. Gatos. Paper before Electrochemical Soc., Ann. Conv., Chicago, Oct. 12-15, 1949. *Electroplating*, 3, No. 4, 138-139 (1949) Dec.

A satisfactory mechanism for corrosion inhibition by metaphosphates is still not available. Data are presented showing the effect of dissolved oxygen on the corrosion rate of Fe in the presence of 60 ppm of metaphosphate. These data prove that dissolved oxygen is beneficial to inhibition and, hence, the mechanism of metaphosphate behavior probably de-

rives, in part, from the presence of oxygen. Data were also obtained for various NaCl concentrations containing 60 ppm inhibitor. Above 50 ppm NaCl the corrosion rate increases rapidly. This is in line with expected action of chlorides in breaking down passivity.—INCO.

## 5.8

**1) The Use of Sodium Benzoate as an Antifreeze and as a Corrosion Inhibitor in Heat Exchange Systems.** W. H. J. Vernon and others. **2) Improved Inhibitive Mixture for Use in Heat Exchange Systems and in Temporary Protective.** Chemical Research Laboratory. 1) *MIRA Bulletin*, Fourth Quarter, 16-21, 1948. 2) Typescript, 1, 1949, June.

1) A 30% sodium benzoate solution can be used as a non-corrosive antifreeze solution, but one disadvantage is the formation of voluminous white deposits at leakage points. Solutions containing glycol or glycerol with 1.5% benzoate do not suffer from this disadvantage and inhibition of the corrosion of steel or various bimetallic contacts is very effective. This work is covered by Brit. Pat. Spec. 598,154.

2) Benzoate is found to be ineffective for inhibiting corrosion of cast iron. Nitrite on the other hand will inhibit attack of cast iron, but causes corrosion of soldered joints. Suitable mixtures of the two will however prevent attack on either of these materials.—BNF.

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## 8.4

**Carter's Research Program Geared to Seeking Answers to . . . \$64 Question.** L. S. McCaslin. *Oil & Gas J.*, 47, No. 3, 205, 207-208 (1948) May 20.

In discussion of Carter's research program, the value of corrosion investigation is described. External casing corrosion was reduced by plastic flow-line nipples. Research is now determining if cathodic protection in this case would be economically desirable. Corrosion research is done both in the field and in the laboratory by Carter Oil Co. Illustrations.

## 8.4.5.8

**Mitigation of Oil Field Corrosion.** P. L. Menaul. *World Oil*, 130, 152-154+ (1950) Jan.

Discussing the effect and cost of corrosion, the author points out underlying causes and describes methods for coping with the trouble. In particular he stresses the use of the aldehydes as inhibitors, illustrating his point by photographs of serious damage sustained before treatment was begun.—GPC.

## 8.4.3.3

**Hydrogenation Plant Steels.** George A. Nelson. *Proceedings, API* (Refining Div.), 29M (III), 163-172; (1949) discussion, 172-174.

Presents recommendations based on the literature and on the experiences of Shell Oil Co. Graphs show limits of stability for C and Cr-Mo steels for various combinations of temperature and pressure. Operating limits of these steels in contact with hydrogen are also charted. Photographs and micrographs show exposed specimens. Cladding was ineffective because of diffusion of hydrogen

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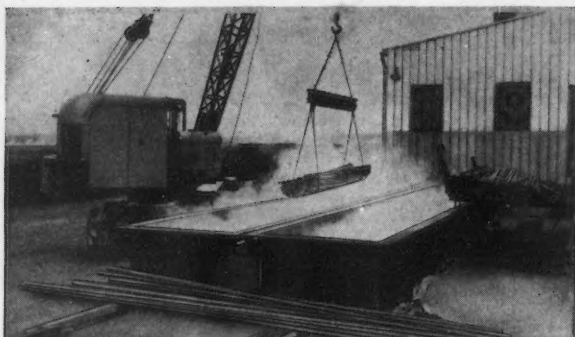
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unless escape holes were provided. Effects of S and NH<sub>3</sub> are also outlined.—BLR.

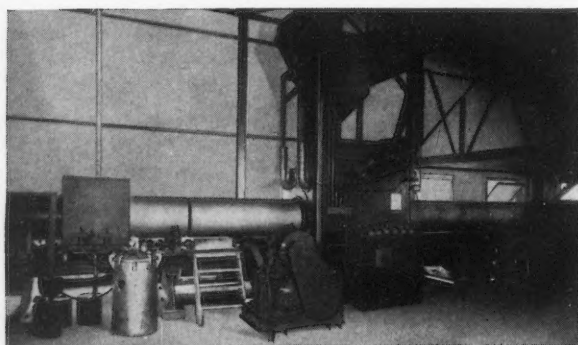
## 8.5.2.1

**Cooperative Corrosion Testing in the Wood Pulp Industry.** T. R. Gaulke and M. A. Scheil. *Corrosion*, 5, 392-401; discussion, 401-402 (1949) Nov.

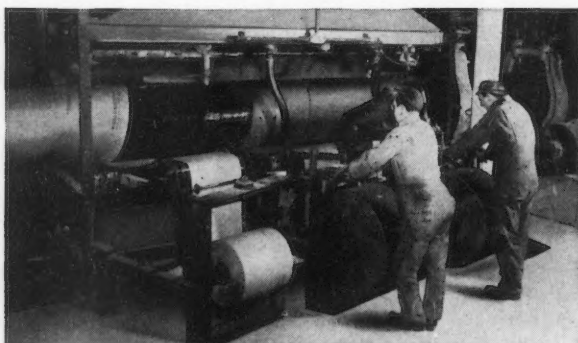
Primary purpose of paper is to show how a cooperative corrosion-testing program can be used to select the proper material for a particular job; and to show how heat treatment, welding, and working this material influence its corrosion resistance, and guide the equipment manufacturer in his methods of fabrication. Includes tables, graphs and illustrations.—BLR.



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